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ANTHROPOLOGY AND HUMAN GROWTH

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There is nothing new about the study of man by man. Man has been observing and commenting about himself for a very long time. In fact, we may suspect that even the earliest torch-bearers of man's progress had an interest in their fellow-creatures—a gastronomical interest. One of man's first discoveries about man probably was that he is edible.

Some epochs later, when dietary habits changed, to be replaced by other equally fascinating and destructive fashions, man's interest in himself had not abated. Still, even among non-predatory anthropologists, the chief motif usually was man as a palaeontological curiosity, man as a racial specimen, man in the mass—seldom the study of man as an individually developing organism.

It was not until well into this century that any considerable body of anthropologists tore themselves away from the absorbing study of defunct individuals, and became aware of the living laboratory awaiting them in the growing human body. In this movement, the names of Franz Boas and C. B. Davenport are outstanding.

A dawning realization that the human child is not merely a little man, but an organism possessing peculiar problems and challenges, turned the attention of many other disciplines to the growing human being as an individual object of study. Such a trend may be seen early, for instance, in the establishment of pediatrics as a separate medical specialty, and in the increasing interest of psychology in problems of child development. Many such fields came into the orbit of human growth as full-blown disciplines, intent upon their own problems, and employing children as subjects only insofar as they were suitable to the study at hand. These fields often remained to study human growth and development as a discipline in its own right.

And in the report of the anthropology section of the A. A. A. S. at its 1931 meeting, human growth may be considered, so to speak, to have come of age:

"In the realm of physical anthropology emphasis centered very largely around the question of growth. . . . Indeed, the sessions devoted to this subject left a rather definite impression that we may be at the beginning of a new era, in which the individual, rather than mass studies, will be foremost. The importance of observing the same individual over the largest possible period was emphasized by nearly every speaker who dealt with any aspect of development."

In the course of this evolution, research has thus tended to shift its interest from the study of a few variables in large samples of humans, at one period of time,

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to the study of many variables in relatively small samples of humans, over long periods of time. In other words, anthropology has become aware of the ontogenetic aspects of the story of man, and aware also that the observation and analysis of human growth present valid anthropological problems (1-4).

The study of human growth gives rise to problems which have an existence within themselves, and call for methods of analysis which are distinctive (5-9). This situation arises in part from the fact that man himself is in many respects a unique animal.

Man has certain structures and physical abilities which, though not unique in a broad biologic sense, are nevertheless at the extremes of a continuum. For example, one easily thinks of brain size, habitual upright posture, language, tool-using hands. Together with these, man has certain growth patterns of infancy and adolescence, and a life-span extending well beyond the reproductive necessities of the species, which make for unusual person-to-person associations. In addition, man has certain environmental relationships which are not completely duplicated by the rest of the biologic world.

These environmental relationships have been penetratingly discussed by Frank (10), who distinguishes four types: geographical, internal, the cultural environment of group life, and the social environment of group living. Human beings operate within these environments, responding in terms of their own "private worlds," through their own inherited physical makeup.

In this inter-relation of behavior to biological characteristics, man is essentially unique, and must be studied by methods particularly suited to his own uniqueness. We must, as Romanell (11) says, find some kind of an explanation of evolution that will fit all the facts of life, and yet make intelligible the difference between the life of man and the rest of living things. Human conduct is not always rational, but there may be a rational interpretation for its irrationality. Greff, director of medical sciences of the Rockefeller Foundation, says "some new organizations of researchers must be evolved to carry on those studies of human phenomena which require years to complete. We have had a foretaste of such studies in the researches on child growth and development. In this field the tendency has been steadily to extend the period under which the individuals are under study."

Since 1929, the Fels Research Institute for the Study of Human Development, at Antioch College, has been engaged in just such a study as Dr. Greff has asked for. The Institute is engaged in what may be called a longitudinal, multidimensional, integrative study of a relatively small sample of the human population. The growth, development and social adjustment of some 300 children, together with their families, are being followed from fetal life through maturity. The complexity of such a study makes it necessary, of course, that many disciplines contribute their skills, and the present personnel includes representatives from anatomy, anthropology, biochemistry, genetics, medicine, physiology and psychology (12).

The general program involves an extensive battery of observations, measurements and tests, within the above-mentioned areas, at repeated intervals, through the life-span. Within the physical growth department, the collection of data and the core of research are centered around changes in body structure, growth progress and health. Thus, techniques and investigations in this department draw heavily upon the disciplines of physical anthropology and medicine. The staff of the physical growth department includes a pediatrician, a physical anthropologist, a specialist in the growth of teeth and jaw, and various assistants trained in x-ray and medical techniques, anthropometry and nutrition analysis. The point of view of the department is strongly longitudinal; that is, analyses are based on repeated measurements and observations of the same individuals during the entire period of growth.

The longitudinal method of studying the development of human beings possesses both advantages and disadvantages (13). A full discussion of these factors is beyond the scope of the present paper. However, it is safe to say that, with the materials we have examined to date, longitudinal data appear to give much superior information on growth trends for every physical, physiological, mental and social factor which we have been able to measure or assay.

The longitudinal method of studying human development has been cited as the outstandingly important item in predictions of trends of research in the second half of the twentieth century. The manipulation of research in this complex area is a procedure in which the anthropologist is truly a key man. Within this area, research in physical growth is a vital part in man's search for greater knowledge of himself.

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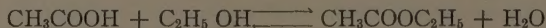
VAPOR PHASE ESTERIFICATION OVER SODIUM ACID SULFATE¹

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INTRODUCTION

The esterification reaction of acetic acid with ethyl alcohol, as shown by the equation,



has long excited the curiosity of chemists and has been studied extensively by both organic and physical chemists. The reaction has been one of the most useful in preparative organic chemistry, a classical example of the law of mass action, and one of the baffling problems in homogeneous catalysis.

Berthelot and St. Gilles (1) obtained experimental results in 1862 from which a value for the liquid equilibrium constant was later determined. The value of 4.0 calculated from their data, is still quoted to students studying the problem of reaction equilibrium, although it is known that this *K* value will vary depending upon the starting proportions of the reaction mixture.

The vapor phase equilibrium value, unlike the liquid phase "constant," should be very nearly a constant for a given temperature throughout an entire range of possible starting compositions. However, the works of the various investigators have yields results from which a true constant for a given temperature cannot yet be deduced. The principal results on vapor phase esterification are now described.

Edgar and Schuyler (2), in 1924, made the first definite attempt to determine an equilibrium constant for the vapor phase reaction. They analyzed the vapor above a liquid equilibrium mixture of alcohol, acid, ester, and water. Their values varied from 347 to 559 for a vapor phase temperature range of 72.6° to 77.6° C.

In 1928, Swietoslawski and Poznanski (3) repeated this work, but with somewhat greater accuracy. Their average numerical value for *K* at 75° C. was reported as 59 ± 10 .

Tidwell and Reid (4) published results of esterification experiments, which showed the value of the equilibrium constant increased as the temperature of the reaction mixture decreased. Their runs were made at fifty degree intervals from 150° to 300° C. The experimental data were obtained from equilibrium runs made over silica gel as the catalyst.

In 1932 Essex and Clark (5) determined the equilibrium constant over silica gel at 150°, 165° and 200° C. Their final values for *K* were arrived at after allowing for association of acetic acid in the vapor state.

The results for the equilibrium constants obtained by Essex and Clark and by Tidwell and Reid are shown in Table I.

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²Presented as a thesis in partial fulfillment of the requirements for the Master of Science degree.

TABLE I

T° C.	Essex Clark	Tidwell Reid
150	33.0	30.9
165	26.4	
200	16.1	24.9
250		12.7
300		8.9

The values obtained by both sets of investigators check rather well at low temperatures but tend to diverge at high temperatures.

Jatkar and Gajendragad (6), 1937 carried out esterification experiments at 230° C. and 260° C. At 260° C. their K value averaged 10, and at 230° C. the values round ran from 9.9 to 12. These values, when checked with Table I appear to coincide rather favorably.

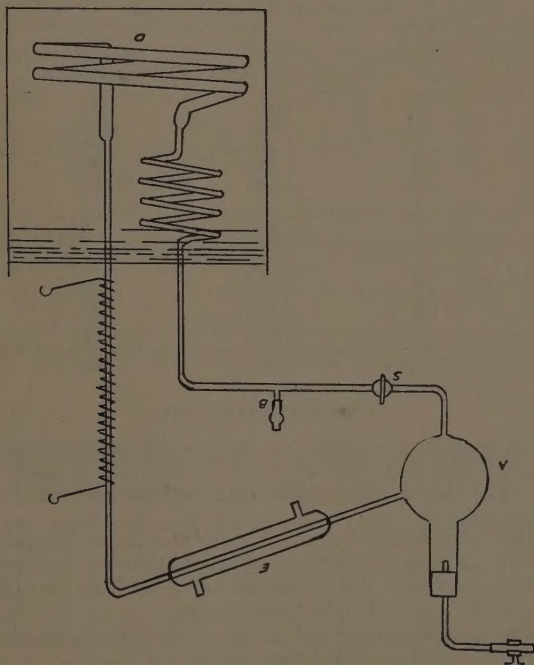


FIG. 1. Equilibrium apparatus.

Reports of vapor phase esterification experiments carried out at 40° C. by Halford and Brundage (7) appeared in 1942. Their final K value of 122 ± 3 was the first to have been calculated from data collected at such a low temperature.

In 1943 Knox and Burbridge (8) reported an equilibrium constant for 125° C. This work was the first to be done on catalytic esterification below 150° C., and the K value so obtained was 45.7 ± 1.4 . The catalyst used was zirconium oxide.

A review of existing literature, then, shows that measurements of a number of the earlier workers produced results which in many cases coincide rather well and appear to have considerable merit for the temperature range in which their investigations were carried out. If these same results are extrapolated to 100° C., the approximate values for the equilibrium expression vary from as low as 45 to as high as 90. This wide range of values indicates the desirability of considerably more work to be done on the problem.

It was the purpose of this work, therefore, to obtain data at 100° C. from which the value of the equilibrium constant could be calculated. The catalytic agent used for the vapor phase runs was sodium acid sulfate.

TABLE II

Esterification sample: ethanol 63.17%, water 31.014%, ethyl acetate 4.154%, acetic acid 1.666%.

Hydrolysis sample: ethanol 62.67%, water 30.768%, ethyl acetate 6.623%, acetic acid 0.000%.

Equilibrium Data at 100° C.					
Run	Time (hrs.)	Reaction	Wt. % Original Acid	Wt. % Final Acid	K. Value
1	20	E	1.666	.0763	75.26
2	22	E	1.666	.0796	72.08
3	16	E	1.666	.0803	71.47
4	10	H	0.000	.0801	71.84
5	8	H	0.000	.0832	69.24
At 125° C.					
1	9	E	1.666	.1163	48.90
2	8	E	1.666	.1203	47.29
3	5	H	0.000	.1218	48.65
4	6	H	0.000	.1180	48.33

EXPERIMENTAL WORK

The materials used were commercial 95% ethyl alcohol, glacial acetic acid, anhydrous ethyl acetate, and distilled water. The catalytic agent was suspended on glass beads. The beads were coated with sodium acid sulfate by immersing them in the molten salt.

The apparatus used in this work was patterned after one designed by Knox and Burbridge (9). A diagram of the equipment is shown in Figure 1.

The constant temperature bath consisted of a 15 liter pyrex glass container. The liquid used in the bath was dibutyl phthalate.

The bath was provided with an electric stirrer, and the temperature was thermostatically controlled to within one degree.

The flask "A," the reaction mixture container, was capped with a one-holed rubber stopper from which extended a small piece of glass tubing. The tubing was tied by a piece of rubber tubing which could be closed by a screw clamp.

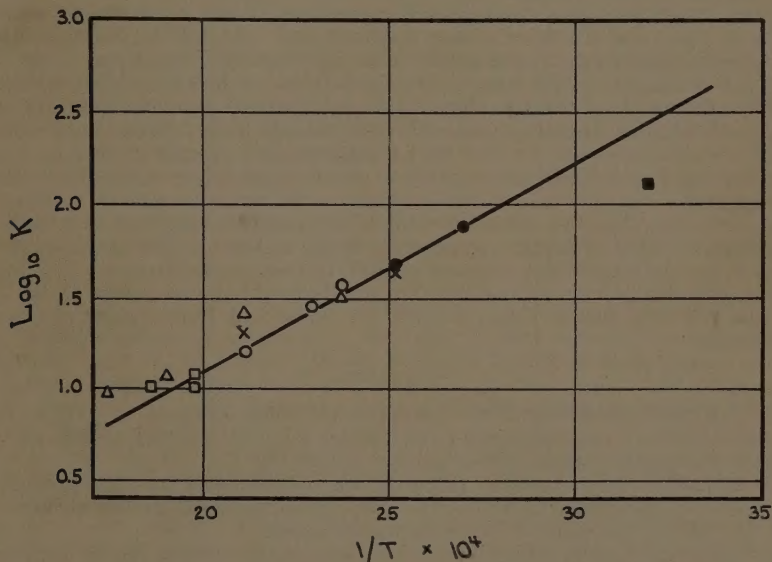
The reaction mixture was allowed to flow slowly through the stopcock "S" into the preheater "C." The sample was here vaporized and allowed to pass into the reaction coil.

This coil was constructed from four feet of twenty millimeter pyrex glass tubing and wound into a continuous coil. This tube contained the catalyst.

From the reaction coil the vapors passed into the condenser "E" and finally back into the flask "A." To prevent excessive condensation of the vapors between the bath and the condenser, the tubing from "D" to "E" was wrapped and heated with No. 20 chromel wire.

Thus the system prepared was a closed one and did afford an opportunity for continuous circulation without the loss of any reactants.

The hydrolysis and esterification samples were prepared by weight and the percentages of acid and ester were checked volumetrically using standard NaOH and standard HCl. The reaction mixtures were stored in an electric refrigerator, and the acid content was checked at intervals to note any change in the sample.



Δ , Tidwell and Reid; $\circ$, Essex and Clark; $\times$, Knox and Burbridge; $\square$, Jatkar and Gajendragad; $\blacksquare$, Halford and Brundage; $\bullet$, this work

FIG. 2. Vapor Phase Esterification Equilibrium.

The compositions of the esterification and hydrolysis samples are given in Table II. At the beginning of a run, the sample was introduced into flask "A," and the screw clamp was left slightly open. The stopcock "S" was opened, and the sample was vaporized, catalyzed and condensed. As soon as the first vapors reached the condenser the screw clamp was closed and the reaction mixture allowed to circulate for several hours.

After some time, approximately a one gram sample was pipetted from the reaction mixture, weighed and titrated against N/100 NaOH.

Circulation of the main sample was begun again and continued for at least another four hours. When the acid content became a constant equilibrium was assumed to have been reached.

At 100° C. equilibrium was reached in about twenty hours and the acid content was very near 0.08%; while at 125° C. reaction time was nearer twelve hours and the acid content, 0.12%.

From the data of Table II, and after allowing for the association of acetic acid to the dimer, using experimental results of Ritter and Simon (10), the average K values for the vapor phase esterification equilibrium reaction were found to be 74.5 ± 3.3 at 100° C. and 48.2 ± 1.3 at 125° C.

The results of this investigation are shown on Figure 2 in the form of a plot of the $\log_{10}K$ against the reciprocal of the absolute temperature. The data here obtained are extrapolated to both higher and lower temperatures and compared with the previous investigations.

From the extrapolation to higher temperatures, it can be seen that all the results of Essex and Clark are closely approximated. At 150° C. our theoretical value checks almost exactly the actual value obtained by Tidwell and Reid. At 250° C., however, our result more nearly checks those of Jatkar and Gajendragad.

When the results of this investigation are extrapolated to a lower temperature; namely, 40° C., our theoretical value diverges sharply from previous data. However, it should be pointed out that we have plotted only average values.

It appears that it would be desirable to obtain more values especially at lower temperatures.

Nevertheless, the close approximation of extrapolated values of this work to experimental values of higher temperature work, makes one feel that the value obtained for the equilibrium constant at 100° C. is a creditable one.

It might also be pointed out that the results of this investigation at 125° C. coincide well with the K value obtained by Knox and Burbridge at the same temperature.

SUMMARY

1. The vapor phase esterification reaction for dilute solutions of ethyl acetate and acetic acid in a predominantly alcohol-water solution over sodium acid sulfate has been studied by a static method at 125° C. and 100° C.

2. At 125° C. the K value of 48.3 ± 1.2 was obtained and is in fair agreement with Knox and Burbridge as well as the extrapolated values of earlier workers.

3. At 100° C. the value of 74.5 ± 3.3 was obtained.

4. Sodium acid sulfate was found to be a suitable catalyst at the temperatures at which this work was carried out. Its catalytic action appeared to be much more pronounced at low temperatures than the action of silica gel or zirconium oxide used by some previous investigators.

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THE EFFECT OF FUNGI ON THE FLAVOR AND COLOR OF TOMATO JUICE

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INTRODUCTION

Many organisms impart a characteristic off flavor to various food products. L. B. Jensen (1) has classified bacteria causing musty flavors on different food products. He states they have never observed molds as the causative agents of true mustiness in foods.

Mold counts are officially employed to determine adulterations in many food products. As commonly used they are also assumed to indicate the general sanitary conditions of the plant. High mold counts would indicate unsatisfactory sanitation. More should be known about the actual effects of microorganisms on the quality of the products.

The effects of fungi and yeast on the flavor of tomato juice were studied to determine whether the use of a highly infected raw product would produce noticeable differences in the flavor of the canned juice.

Some of the organisms were grown with reduced oxygen supply to approximate conditions encountered in commercial canning.

METHODS

Twenty-eight molds and yeasts (see Table I) were obtained from Dr. M. D. Heise¹ and Dr. W. D. Gray.² All the available tomato pathogens were selected including *Rhizopus nigricans*, *Rhizoctonia* sp., *Fusarium* sp., *Colletotrichum* sp., and *Alternaria* sp. The remaining organisms were chosen as possible contaminating agents from the air.

One hundred ml. of a commercial brand of Ohio tomato juice were pipetted into 250 and 125 ml. Erlenmeyer flasks. The flasks and juice were autoclaved for 15 minutes at 10 lbs. pressure. The smaller flasks were used to determine the effect of a reduced oxygen content on the growth since after the addition of the juice to the flask an air space of one-half inch remained, leaving only a small surface area exposed to the atmosphere. The juice was inoculated with the organisms and the tests and uninoculated controls run in triplicate. The samples were incubated at room temperature. After a week of incubation, 10 ml. of the juice from each flask were removed and autoclaved. An Abbé refractometer reading was made, pH determined by a Beckman potentiometer, and the flavor, odor and color of each sample were recorded. The flasks were incubated for a total of five weeks and the determinations made weekly.

RESULTS

The results of weekly determination of pH, refractive indices and the final odor, flavor and color are recorded in Table I. The organisms in the 250 ml. flask produced a greater growth with greater changes in pH, refractive indices, color, odor and flavor than those grown in the 125 ml. flasks. The rate of the physiological changes was greatly decreased in the smaller flasks. With the weekly removal of 10 ml. of the juice, larger surface areas were exposed so that by the fourth and fifth week the difference in growth in the small vs. large flasks was less pronounced.

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²Botany Department, Ohio State University.

TABLE I
EFFECT OF 28 MICROORGANISMS ON pH, REFRACTIVE INDICES, COLOR, TASTE AND ODOR OF TOMATO JUICE

ORGANISM	pH					REFRACTOMETER READING					COLOR	TASTE	ODOR
	1st Week	2nd Week	3rd Week	4th Week	5th Week	1st Week	2nd Week	3rd Week	4th Week	5th Week			
Control (not inoculated)	4.28	4.26	4.29	4.28	4.28	1.3412	1.3436	1.3439	1.3430	1.3411	Tomato	Normal	Normal
<i>Alternaria</i> sp. (1)*	4.24	4.10	3.83	4.76	6.41	1.3427	1.3449	1.3393	1.3358	1.3362	Black	Musty	Musty
<i>Alternaria</i> sp. (2)**	4.30	4.18	4.28	4.26	4.40	1.3429	1.3420	1.3443	1.3415	1.3372	Tomato	Normal	Normal
<i>Aspergillus niger</i> 1	4.04	4.04	5.60	6.74	6.55	1.3401	1.3352	1.3351	1.3345	1.3336	Dark Brown	Musty	Musty
<i>Aspergillus niger</i> 2	4.17	4.20	4.58	4.78	6.98	1.3416	1.3404	1.3398	1.3376	1.3361	Light Brown	Musty	Musty
<i>Aspergillus herbariorum</i> 1	4.13	4.23	7.36	7.86	9.08	1.3418	1.3720	1.3365	1.3341	1.3342	Dark Brown	Bitter	Pungent
<i>Aspergillus herbariorum</i> 2	4.30	4.22	4.22	4.26	4.37	1.3421	1.3422	1.3365	1.3378	1.3359	Tomato	Normal	Normal
<i>Baurea</i> sp. 1	4.09	4.75	8.42	8.72	8.80	1.3383	1.3374	1.3358	1.3379	1.3362	Orange	Flat	Musty
<i>Baurea</i> sp. 2	4.20	4.22	4.44	4.44	4.79	1.3401	1.3399	1.3398	1.3392	1.3380	Tomato	Flat	Musty
<i>Cephalosporium</i> sp. 1	4.15	8.01	8.87	9.04	9.11	1.3385	1.3327	1.3350	1.3348	1.3348	Brick Red	Flat	Flat
<i>Cephalosporium</i> sp. 2	4.21	4.23	4.42	4.88	5.39	1.3424	1.3413	1.3395	1.3387	1.3362	Brick Red	Flat	Flat
<i>Choanephora</i> sp. 1	4.13	8.87	9.06	8.96	8.99	1.3370	1.3359	1.3355	1.3352	1.3358	Brick Red	Bitter	Pungent
<i>Choanephora</i> sp. 2	4.20	4.24	4.46	4.70	4.88	1.3421	1.3416	1.3393	1.3388	1.3384	Red	Bitter	Pungent
<i>Colletotrichum</i> sp. 1	4.27	8.09	9.09	8.98	9.44	1.3411	1.3377	1.3350	1.3355	1.3362	Brown Orange	Musty	Pungent
<i>Colletotrichum</i> sp. 2	4.21	4.82	4.93	5.20	5.86	1.3421	1.3418	1.3399	1.3392	1.3387	Orange	Musty	Normal
<i>Debaryomyces lactis</i> sp. 1	4.06	4.28	7.80	8.36	8.90	1.3383	1.3370	1.3354	1.3358	1.3365	Brown	Bitter	Pungent
<i>Debaryomyces lactis</i> sp. 2	4.17	4.21	4.18	4.24	5.23	1.3423	1.3420	1.3396	1.3396	1.3372	Tomato	Bitter	Normal
<i>Diplosporium</i> sp. 1	4.33	4.28	4.66	8.86	9.53	1.3415	1.3409	1.3489	1.3388	1.3357	Brown	Flat	Pungent
<i>Diplosporium</i> sp. 2	4.22	4.11	4.23	4.23	7.32	1.3443	1.3443	1.3448	1.3450	1.3380	Tomato	Bitter	Normal
<i>Eurolium</i> sp. 1	4.27	4.70	8.42	9.03	8.83	1.3402	1.3358	1.3354	1.3354	1.3363	Light Brown	Bitter	Pungent
<i>Eurolium</i> sp. 2	4.27	4.31	4.46	4.92	6.28	1.3422	1.3417	1.3396	1.3393	1.3382	Tomato	Bitter	Normal
<i>Fusarium</i> sp. 1	4.23	4.29	5.22	6.81	9.40	1.3402	1.3389	1.3364	1.3365	1.3362	Orange Brown	Flat	Pungent
<i>Fusarium</i> sp. 2	4.24	4.16	4.23	4.45	8.91	1.3422	1.3420	1.3418	1.3373	1.3380	Tomato	Sour	Sour

TABLE I—(Continued)

ORGANISM	pH					REFRACTOMETER READING					COLOR	TASTE	ODOR
	1st Week	2nd Week	3rd Week	4th Week	5th Week	1st Week	2nd Week	3rd Week	4th Week	5th Week			
<i>Myrothecium</i> sp.	4.27	4.21	4.27	6.12	7.06	1.3422	1.3418	1.3420	1.3364	1.3358	Tomato	Bitter	Sour
<i>Myrothecium</i> sp.	4.28	4.96	5.22	5.41	5.44	1.3423	1.3421	1.3412	1.3396	1.3372	Tomato	Bitter	Normal
<i>Monilia</i> sp. 1	4.37	5.40	8.92	9.15	9.58		1.3376	1.3374	1.3371	1.3373	Dark Brown	Flat	Pungent
<i>Monilia</i> sp. 2	4.26	4.37	4.67	4.73	5.62	1.3421	1.3404	1.3381	1.3381	1.3379	Tomato	Flat	Pungent
<i>Mucor</i> sp. 1	4.29	4.12	5.54	6.08	8.53	1.3382	1.3372	1.3364	1.3361	1.3370	Orange	Sour	Sour
<i>Mucor</i> sp. 2	4.28	4.37	4.94	5.81	6.97	1.3342	1.3396	1.3392	1.3384	1.3386	Tomato	Sour	Sour
<i>Paeclomyces</i> sp. 1	4.17	4.18	6.32	7.17	6.83	1.3382	1.3365	1.3351	1.3360	1.3370	Dark Brown	Musty	Musty
<i>Paeclomyces</i> sp. 2	4.24	4.21	4.43	4.97	5.02	1.3441	1.3403	1.3395	1.3387	1.3373	Dark Brown	Musty	Musty
<i>Penicillium</i> sp. 1	4.53	6.75	7.46	7.58	8.11	1.3386	1.3358	1.3370	1.3363	1.3379	Tomato	Flat	Off
<i>Penicillium</i> sp. 2	4.23	4.67	4.98	5.75	6.02	1.3408	1.3398	1.3372	1.3379	1.3378	Bright Red	Flat	Off
<i>Pichia</i> sp. 1	4.21	4.31	4.98	6.64	7.76	1.3387	1.3371	1.3365	1.3363	1.3370	Orange	Sour	Sour
<i>Pichia</i> sp. 2	4.18	4.20	4.55	5.76	7.31	1.3393	1.3399	1.3382	1.3380	1.3376	Orange	Sour	Sour
<i>Rhizotonia</i> sp. 1	5.10	5.96	6.98	7.44	8.09	1.3392	1.3384	1.3360	1.3353	1.3361	Dark Red	Bitter	Off
<i>Rhizotonia</i> sp. 2	4.26	4.24	4.38	5.12	6.95	1.3398	1.3392	1.3385	1.3385	1.3371	Dark Red	Bitter	Off
<i>Rhizopus nigricans</i> 1	4.70	5.21	5.94	6.72	7.33	1.3398	1.3382	1.3377	1.3378	1.3367	Dark Brown	Sour	Sour
<i>Rhizopus nigricans</i> 2	4.30	4.29	4.36	4.3	4.92	1.3396	1.3402	1.3390	1.3387	1.3381	Light Brown	Sour	Sour
<i>Sacharomyces naksoni</i> 1	4.93	5.21	5.78	7.25	7.62	1.3382	1.3374	1.3390	1.3370	1.3362	Tomato	Sour	Sour
<i>Sacharomyces naksoni</i> 2	4.26	4.22	4.91	5.83	7.04	1.3406	1.3396	1.3381	1.3387	1.3370	Tomato	Sour	Yeast
<i>Schizosaccharomyces</i> sp. 1	4.24	4.22	4.23	4.02	5.95	1.3426	1.3422	1.3430	1.3430	1.3419	Tomato	Sour	Yeast
<i>Schizosaccharomyces</i> sp. 2	4.21	4.18	4.33	4.87	4.82	1.3421	1.3423	1.3428	1.3430	1.3430	Tomato	Sour	Yeast
<i>Schizosaccharomyces octosporus</i> 1	4.20	4.33	4.31	4.33	4.96	1.3433	1.3419	1.3391	1.3378	1.3373	Light Tomato	Sour	Yeast
<i>Schizosaccharomyces octosporus</i> 2	4.22	4.20	4.38	4.56	4.54	1.3421	1.3426	1.3433	1.3431	1.3428	Light Tomato	Sour	Yeast
<i>Scopulariopsis</i> sp. 1	4.25	7.85	9.02	9.04	9.46	1.3375	1.3370	1.3355	1.3357	1.3366	Dark Brown	Bitter	Musty
<i>Scopulariopsis</i> sp. 2	4.20	4.22	4.25	4.47	8.43	1.3440	1.3444	1.3430	1.3399	1.3382	Tomato	Normal	Normal

TABLE I—(Continued)

ORGANISM	pH					REFRACTOMETER READING					COLOR	TASTE	ODOR
	1st. Week	2nd Week	3rd Week	4th Week	5th Week	1st Week	2nd Week	3rd Week	4th Week	5th Week			
<i>Syncephalastrum cinereum</i> 1	4.18	4.07	4.74	4.61	9.04	1.3412	1.3360	1.3389	1.3370	1.3354	Light Brown	Flat	Off
<i>Syncephalastrum cinereum</i> 2	4.16	4.13	4.24	4.27	4.31	1.3442	1.3435	1.3425	1.3450	1.3386	Tomato	Normal	Normal
<i>Torula</i> sp. 1	4.68	5.24	5.93	6.76	7.41	1.3393	1.3384	1.3375	1.3378	1.3372	Deep Red	Sour	Yeasty
<i>Torula</i> sp. 2	4.03	4.18	4.65	4.98	5.74	1.3407	1.3398	1.3399	1.3391	1.3386	Tomato	Sour	Yeasty
<i>Trichoderma</i> sp. 1	4.21	4.59	8.44	8.84	9.04	1.3409	1.3394	1.3364	1.3360	1.3364	Dark Brown	Flat	Off
<i>Trichoderma</i> sp. 2	4.33	4.24	4.42	7.32	7.69	1.3452	1.3432	1.3409	1.3390	1.3368	Dark Brown	Slight Sour	Sour
<i>Verticillium</i> sp. 1	5.06	5.45	7.32	8.44	9.60	1.3379	1.3381	1.3366	1.3373	1.3366	Dark Brown	Sour	Musty
<i>Verticillium</i> sp. 2	4.17	4.28	4.56	5.32	5.95	1.3424	1.3413	1.3398	1.3382	1.3385	Brown	Sour	Musty
<i>Hansenula</i> sp. 1	5.03	5.42	5.87	6.12	6.99	1.3426	1.3389	1.3372	1.3382	1.3360	Lt. Tomato	Sour	Yeasty
<i>Hansenula</i> sp. 2	4.19	4.68	4.97	5.62	5.73	1.3443	1.3438	1.3410	1.3391	1.3389	Tomato	Sour	Yeasty

*100 ml. juice in 250 ml. flask.

**100 ml. juice in 125 ml. flask (reduced oxygen content).

In the 250 ml. flasks an increase in pH was accompanied by a decrease in the refractometer readings indicating a decrease in total solids content. Those organisms producing the most pronounced pH changes included *Aspergillus herbariorum*, *Choanephora* sp., *Colletotrichum* sp., *Diplosporium* sp., *Fusarium* sp., *Scopulariopsis* sp., *Trichoderma* sp., *Verticillium* sp., *Cephalosporium* sp. and *Monilia* sp. The pH of these organisms at the end of the fifth week was over nine. The organisms giving the greatest decrease in refractometer readings were *Aspergillus niger*, *Aspergillus herbariorum*, *Cephalosporium* sp. and *Syncephalastrum cinereum*.

As incubation progressed color changes became more marked. The fungi at the end of the fifth week produced colors ranging from an orange to a brick red to a dark brown. Most of the yeasts produced an orange white color. A change in color was accompanied with the production of off tastes and odors. At the end of the first week no off odors or flavors were detected in the flasks containing fungi (Table I).

Data on each organism was recorded as given in Table II. This table shows the early change in color, taste and odor produced by *Aspergillus niger*.

TABLE II
THE EFFECT OF *Aspergillus niger* ON PH REFRACTIVE INDICES, COLOR, TASTE AND ODOR

Organism	No. of Weeks	pH	Refractometer Reading	Color	Taste	Odor
<i>Aspergillus niger</i>	1	4.04	1.3401	Normal	Normal	Normal
	2	4.94	1.3352	Dark Brown	Musty	Musty
	3	5.60	1.3351	" "	"	"
	4	6.74	1.3345	" "	"	"
	5	6.55	1.3336	" "	"	"
Reduced oxygen content	1	4.17	1.3416	Normal	Normal	Normal
	2	4.20	1.3404	"	"	"
	3	4.58	1.3398	"	"	"
	4	4.78	1.3376	"	"	"
	5	6.98	1.3361	Light brown	Musty	Musty

CONCLUSIONS

1. pH values increased progressively with the length of incubation.
2. As the pH values resulting from mold growth increased, the refractive indices decreased.
3. Color changes occurred after the first week ranging from orange to brick red to dark brown.
4. In most samples of moldy product off flavors and odors were produced between the second and third week. Yeast produced sour flavors and yeasty odors within the first week of incubation.
5. Since the development of molds depends in part upon an adequate supply of oxygen, it is obvious that commercial canners need not be concerned about the development of off flavors from these organisms after the product is effectively canned or bottled. On the other hand, it is possible that off flavors can be developed from molds growing on tomato fruits or the crushed product prior to the sterilization and inclosure in receptacles which greatly limit the supply of oxygen. This contamination can occur in the farmers' fields, at the cannery yard, receiving station, on conveyor belts, pumps and other plant equipment.

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NEW COLEOPTERA WITH NOTES
(ELATERIDAE, BUPRESTIDAE AND CERAMBYCIDAE)

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Lacon floridanus n. sp.

Female.—Form robust, elongate, resembling *L. oblecta* (Say) in outline. Ground color dark brown; surface clothed with rather broad, pointed, elongate, gray scales which are broader above than beneath.

Head broadly concave on front; surface closely, coarsely punctured; eyes small; antennae extending to little beyond middle of pronotum when laid along side, scape stout, second segment wider than long, third slightly shorter than scape, following segments gradually decreasing in length, third to tenth inclusive serrate, eleventh oval, as long as third, scape and second segment with much longer pubescence.

Pronotum slightly longer than wide, widest at middle, much wider at base than at apex; sides broadly rounded in front, sinuate near hind angles which are strongly divergent; disk convex, flattened transversely at apex, strongly depressed each side at base forming raised area in front of scutellum, hind angles carinate; surface densely, coarsely punctured, leaving narrow smooth area extending some distance in middle. *Scutellum* elongate, obtusely rounded in rear.

Elytra at base as wide as base of pronotum; sides subparallel near base, converging to apical fifth, then broadly rounded to suture; disk convex, basal depressions deep; surface with rows of coarse punctures, narrower than interspaces near suture, becoming larger than interspaces laterally, interspaces with fine punctures near suture, larger laterally.

Prosternum densely, coarsely punctured, antennal grooves diverging anteriorly, extending nearly to coxal cavities, tarsal grooves lacking. Abdomen beneath finely punctured in middle, punctures becoming larger laterally, last visible sternite obtusely rounded, densely punctured over entire surface. Legs slender.

Length 19.5 mm.; width 6.1 mm.

Holotype ♀ collected at Coral Gables, Fla., May, 1948, by H. F. Strohecker in collection of author.

Lacon mexicanus (Cand.)

Adelocera mexicana Candèze, 1857, Mém. Soc. Liège, 12:70; Champion, 1894, Biol. Centr. Amer., Col., 3:259, 260, pl. 11, fig. 1.

Adelocera nobilis Fall, 1932, Can. Ent., 64:58.

Adelocera mexicana, Van D., 1932, Proc. Cal. Acad. Sci., 20:293.

Adelocera nobilis and *mexicana*, Fall, 1934, Jour. N.Y. Ent. Soc., 42:7.

Adelocera mexicana, Van D., 1943, Pan-Pacific Ent., 19:44.

A ♂ specimen collected in Ross Hammock, Dade Co., Fla., by H. F. Strohecker and a ♀ labeled Florida, Wenzel Collection, agree very well with a ♀ taken in Santa Rita Mts., Ariz., July 13, by D. J. & J. N. Knull.

Pyrophorus havaniensis (Cast.)

Figs. 2 and 3

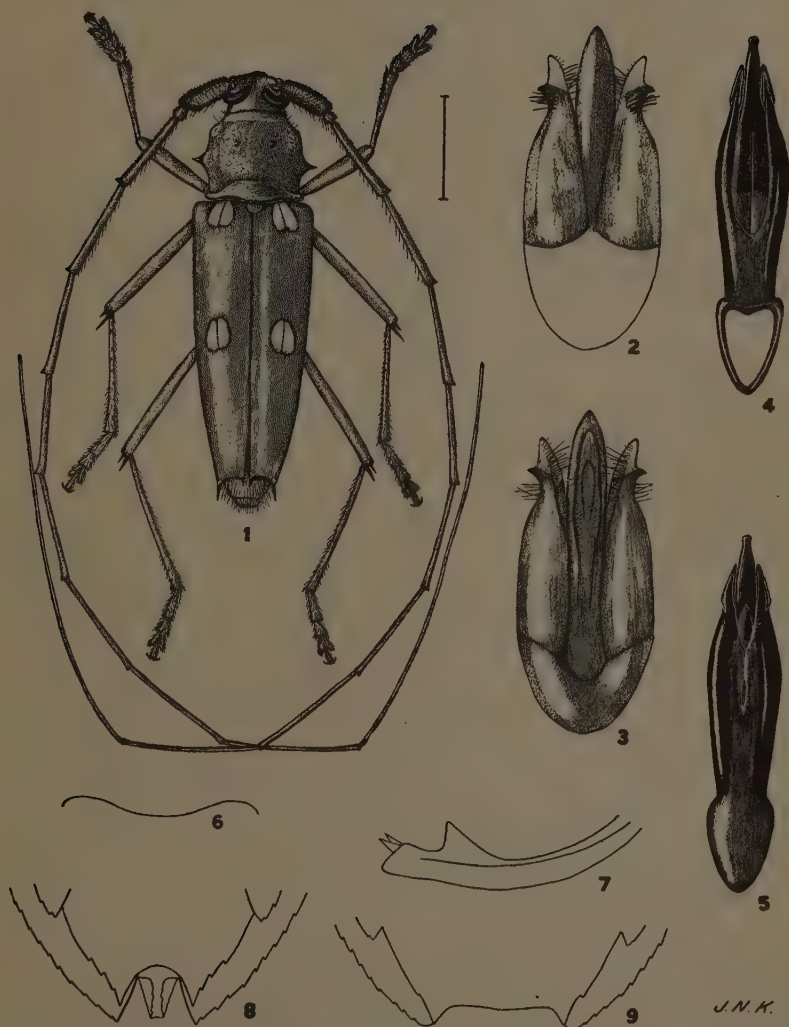
Stilpnus havaniensis Castelnau, 1840, Hist. Nat. Ins., Col., 1:236; Jacq. du Val, 1857, Sagra's Hist. Cuba, 7:73, pl. 7, figs. 14-18; Candèze, 1863, Mém. Soc. Sc. Liège, 17:29; Champion, 1896, Biol. Centr.-Amer., Col., 3:469, pl. 20, fig. 26.

Pyrophorus causticus Germar, 1841, Zeitschr. Ent., 3:36.

Pyrophorus impressifrons Strum, 1843, Cat. Ins. Sammlung Käf., p. 67.

Specimens¹ of this Cuban species labeled Miami, May 10, 1948 and Dade Co., Florida, May 24 and June, 1948, were collected by H. F. Strohecker.

¹Determination verified by R. H. Arnett through C. F. W. Muesebeck.



1. *Eburia stroheckeri* n. sp. ♂. (Line equals 5 mm.) 2. *Pyrophorus havaniensis* Cast. ♂ genitalia, dorsal view. 3. Ventral view of number 2.

Chrysobothris distincta Gory. 4. ♂ genitalia, dorsal view. 5. Ventral view of number 4. 6. Clypeal margin. 7. Anterior tibia of ♂. 8. Last visible sternite of ♀. 9. Last visible sternite of ♂.

It differs from the other four species recorded from the United States by Hyslop² by elongate cuneate elytra, which are divaricately spinose at apices.

***Chrysobothris distincta* Gory³**

Figs. 4, 5, 6, 7, 8 and 9.

1841, Monogr. Bupr. Sup., 4:176, pl. 30, fig. 1171; Waterhouse, 1887, Biol. Centr.-Amer. Col. 3, pt. 1, 45; Gemminger & Harold, 1869, Cat. Col., 5:1425; E. Saunders, 1871, Cat. Bupr., 97; Kerremans, 1892, Mém. Soc. Ent. Belg., 1:212; Wystman, 1903, Genera Ins., fasc. 12, 186; Obenberger, 1940, Sborn. ent. Praze., 18:93.

Two ♂ specimens labeled "Cal." were in the Andrew Bolter collection, now at Illinois State Natural History Survey. A ♀ in collection of author with same label indicates that it should be included in our fauna as stated by Obenberger.

It runs to *C. peninsularis* Schffr. in Fisher's key⁴ but can be separated by its more elongate form, structure of male genitalia and deeper indentation of last visible sternite of ♀.

***Eburia stroheckeri* n. sp.**

Fig. 1.

Male.—Form elongate, resembling *distincta* Hald. Above and beneath light reddish brown; abdomen darker, legs light yellow, tarsi and apices of tibiae brown. Each elytron with two oval contiguous, eburneous spots at base and at middle. Densely clothed above and below with very short recumbent pubescence, lacking around elytral spots.

Head deeply transversely grooved back of clypeus, longitudinally grooved between elevated antennal tubercles; surface rugose; eyes separated above by more than diameter of upper lobe; antennae extending over five segments beyond apices of elytra, scape robust, concave near base, three following segments stouter than outer ones, second about as long as broad, following segments gradually increasing in length, eleventh nearly as long as entire body, segments three to ten inclusive with blunt spines on outside at apices, scape rugose, scabrous, four following segments scabrous, third and following segments flattened, carinate on outside, pubescence corresponding to body, longer hairs beneath on first five segments.

Pronotum wider than long, wider at base than at apex; basal margin sinuate; side margin irregular, with large acute brown spine in middle, an obtuse tubercle between spine and front margin; disk convex, with transverse depression back of apex and a like sinuate area near base, an obtuse brown spine in front of middle on each side; surface rugose. Scutellum wider than long, rounded in rear.

Elytra at base wider than base of pronotum, widest at base; sides converging to apical fifth, then broadly arcuate to bispinose apices, outer spine much longer than sutural spine; disk convex, humeral depressions deep, eburneous spots raised; surface minutely punctate, punctures concealed by vestiture, larger and more evident on denuded areas around spots.

Body beneath minutely punctate, punctures concealed by vestiture, with few erect longer hairs. Legs slender; middle and posterior femora bispinose at apices, inner spine much longer.

Length 21.3 mm.; width 6 mm.

Female.—Differs from ♂ by being more robust with shorter antennae, extending beyond apices of elytra a little over three segments.

Holotype ♂ and allotype collected in coitu in Matheson Hammock, Dade Co., Florida, June 4, 1948, by H. F. Strohecker. Type material in collection of author.

This species is close to *E. jamaicae* Fislr.⁵ but both male and female antennae are carinate and spinose. Elytra spots lack dark areas too. It is distinguished from *E. distincta* Hald. which it resembles, by having longer, spinose antennae in both sexes.

The writer is indebted to Dr. Strohecker for specimens mentioned in this paper.

²J. A. Hyslop, Proc. Ent. Soc. Wash. 19: 1-12, 1917.

³Determined by W. S. Fisher.

⁴W. S. Fisher, Misc. Publ. 470, U.S.D.A., 1-275, 1942.

⁵W. S. Fisher, Torreia, 10: 6, 1942.

THE LABORATORY CULTIVATION AND DEVELOPMENT OF THE MYXOMYCETES *PHYSARELLA OBLONGA* AND *PHYSARUM DIDERMOIDES*¹

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The literature relevant to the cultivation of myxomycete plasmodia on artificial media reveals only one record of the cultivation of *Physarella oblonga* (Berk. & Curt.) Morgan and but two records of the laboratory cultivation of *Physarum didermoides* (Ach.) Rost. Gilbert (1931) stated that in a few instances sporangia of the first species had been obtained by placing spores on slightly acidified corn meal agar; aside from this one statement the writer has found no other references concerning the culture *P. oblonga*, although the species has received some cytological and morphological study. Bisby (1914) described capillitium development, and the gross details of sporangium development of this species were described and figured by Emoto (1934); both Bisby's and Emoto's observations, however, were made on naturally occurring material. Constantineanu (1906), in an extensive paper on the development of Myxomycetes, described the cultivation of *P. didermoides* on various types of media but included no figures and made no statement concerning maintenance of the species in culture by means of plasmodial transplants. Kambly (1939) stated that he was able to obtain plasmodia of *P. didermoides* on carrot decoction agar but that on this medium the plasmodia did not flourish and never completed their life cycles. The writer has had considerable success with the culture of both species and finds them well-suited for the demonstration of sporangial development as well as the illustration of pigmented and non-pigmented plasmodial types. Both are slow-growing when compared with such a species as *Physarum polycephalum* Schw., but they grow rapidly enough that after twelve or fourteen days inocula for thirty or forty cultures may be obtained from a single petri plate culture.

MATERIALS AND METHODS

Two types of media have been employed in these studies: (1) corn decoction agar, prepared by grinding 25-50 gms. of field corn, adding 500 ml. of distilled water, autoclaving for one hour at fifteen pounds pressure, filtering, adding enough distilled water to bring the total volume to one liter, adjusting to pH 5.2-5.4, adding 15 gms. of agar and sterilizing; (2) corn decoction agar, as prepared above, with 25 gms. of filter paper (finely divided by triturating wet in a mortar) suspended in each liter. Both species grew quite well on both types of media; because of the greater ease of preparation, plain corn decoction agar was used in most of the work.

Smith (1929) has shown that spores of various species of Myxomycetes remain viable for many years, but so far the writer has had consistently better results with spores not over two or three years old. Unsterilized medium may be used, but, because these plasmodia grow slowly, it is best to use sterile medium in order to hold contamination to a minimum, although even with sterile medium the cultures are never completely free of other organisms.

CULTIVATION OF *PHYSARELLA OBLONGA*

Spores from a two months old collection of this species, when placed in a drop of distilled water in a corn decoction agar slant, germinated and in fifteen days

¹Paper from the Department of Botany and Plant Pathology, The Ohio State University, Columbus 10, Ohio. No. 509.

or less small yellow plasmodia were visible. Some variation in the time required for plasmodium formation is to be expected, since age, vitality of the spores, and other factors undoubtedly influence both spore germination and plasmodium growth. After plasmodia had appeared in the test tubes they were maintained in the vegetative stage by transferring small blocks of agar, on which there were bits of plasmodia, to fresh medium in 75 mm. petri dishes. Subsequent transfers were made in the same manner. If cultures are stored in the dark, subcultures need not be made at lesser intervals than three weeks. By such methods the species was maintained in culture continuously for nine months; Fig. 2 shows a nine day old culture of *P. oblonga*; Fig. 5 shows a bit of plasmodium enlarged four diameters.

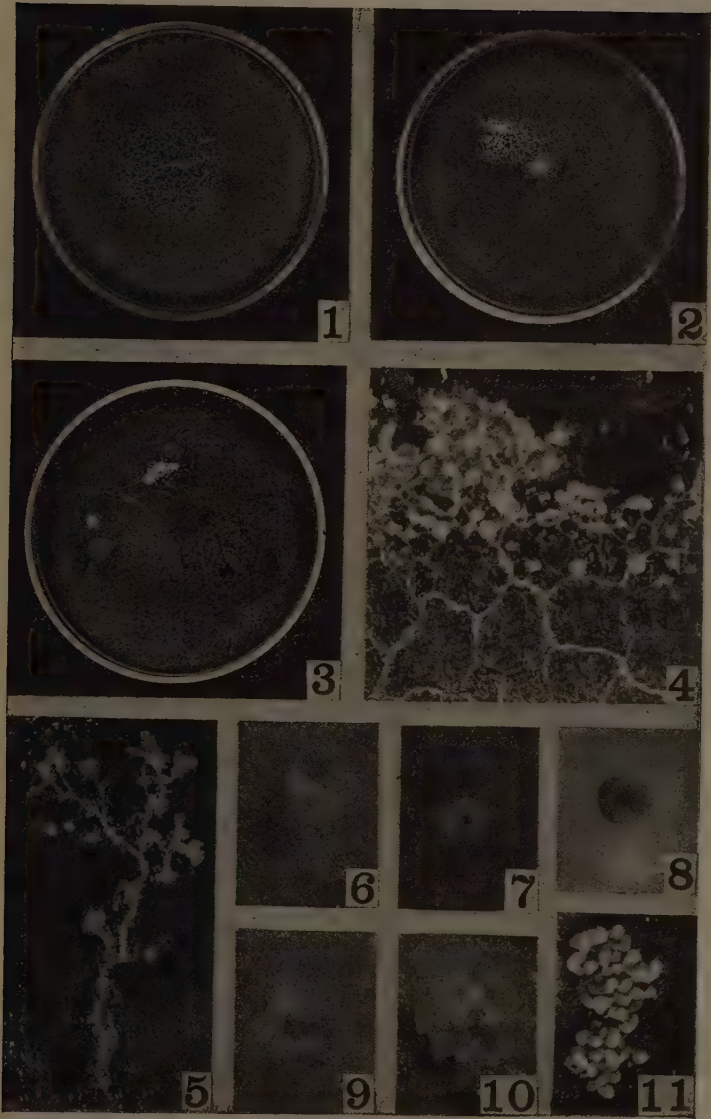
In order to determine if light has any effect upon fruiting, cultures were placed both in light and darkness. Of fifty cultures placed in the dark, fruiting bodies were formed in but two, and, of course, all of these cultures were exposed to light for short periods, since they were examined daily; sporangia appeared in forty out of sixty cultures which were placed in the light. Thus, light affects this species in the same way as previously reported for other species with yellow plasmodia (Gray, 1938). Under laboratory conditions, if plasmodia are left undisturbed, fruiting bodies formed in 15-18 days, while if they are covered with black cloth or placed in a drawer, plasmodia may remain in the active vegetative state for periods as long as seventy days provided the agar substrate does not become dry.

The time required for the development of sporangia from plasmodium is 11-12 hours, once sporangial formation has started. Fruiting is manifested when enlargements appear in the larger strands of the plasmodium (Fig. 6); protoplasm flows into these enlargements and they become still larger with the final result that the strands of plasmodium connecting them disappear. Shortly after this, an umbilicus appears in the top of each globule of protoplasm (Fig. 7) and soon definite stipes are formed. The stipes gradually elongate, and just before maximum length is attained, the stipe bends just below the developing sporangium, and thus the sporangia are typically nodding although in some instances they may be borne upright. Sporangia retain the same yellow color as the plasmodium until final form is attained, and then they gradually darken; however, as soon as the stipes become apparent, they gradually darken from the basal portion upward. Emoto (1934) has figured the various stages in the development of sporangia of this species; all such stages are not shown here.

Both plasmodiocarpous and sporangial types of fruiting bodies are formed by *P. oblonga* in its natural habitats; however, plasmodiocarps have appeared in only a few cultures. It has been found that sporangia are more like naturally occurring fruitings when they are formed under drier conditions; therefore, when the fruiting process is once initiated, it is advisable to remove the petri dish covers. Atypical sporangia and plasmodiocarps are generally formed when the plasmodial enlargements are irregularly shaped (Figs. 9 and 10). The type of formation in Fig. 8 may give rise to a typical sporangium but more frequently develops into a fruiting body with a saddle-shaped sporangium which is suggestive of a minute *Helvella*

EXPLANATION OF PLATE I

FIG. 1. Nine-day old culture of *P. didermoides*. $\times \frac{3}{8}$. FIG. 2. Nine-day old culture of *P. oblonga*. $\times \frac{3}{8}$. FIG. 3. Early stage in the fruiting process of *P. didermoides*, shortly after sporangia have been delimited. $\times \frac{3}{8}$. FIG. 4. Enlarged portion of plasmodium of *P. didermoides*. $\times 4$. FIG. 5. Enlarged portion of plasmodium of *P. oblonga*. $\times 4$. FIG. 6. Enlargement in plasmodium of *P. oblonga* which is indicative of initiation of the fruiting process. $\times 10$. FIG. 7. Typical umbilicate immature sporangium of *P. oblonga*. $\times 10$. FIGS. 8, 9, 10. Plasmodial enlargements which give rise to atypical sporangia. $\times 10$. FIG. 11. Mature sporangia of *P. didermoides*. $\times 4$.



ascocarp. Spores from fruiting bodies developed in culture are viable and will germinate and produce swarm cells and plasmodia when placed upon fresh medium; however, no viable sclerotia have been obtained thus far.

CULTIVATION OF *PHYSARUM DIDERMOIDES*

White plasmodia of this species were obtained by the same method as that employed for the preceding species. Plasmodia were obtained in about fifteen days after spores from a five months' old culture were sown. Of the various non-pigmented plasmodia that have been cultured by the writer, this form is probably the most suitable for laboratory cultivation. The plasmodia are quite tolerant of mechanical injury, and hence subcultures may be made employing very small amounts of plasmodium. Sporangia are formed in either light or darkness, the average time of fruiting for forty cultures being twenty-one days after the cultures were made. In order to maintain the species in its vegetative state, subcultures should be made every 18-20 days. In this manner, *P. didermoides* has been maintained in culture continuously for over six months. Once a culture is established, little care need be observed so far as the maintenance of sterile conditions is concerned, since this species is strongly mycophagous and bacteriophagous, and contaminants are rarely able to become established. Plasmodia of this species are shown in Figs. 1 and 4.

The fruiting process in this species requires 8-10 hours from initiation to completion and differs somewhat from this process as seen in *P. oblonga*; this should be expected since sporangia of *P. oblonga* are not crowded together as in *P. didermoides*. In the latter species instead of the appearance of enlargements in the plasmodial strands, initiation of the fruiting process is manifested when all of the protoplasm of the plasmodium flows into a solid lump. A few hours after this, pearly-white, discrete sporangia may be observed (Fig. 3). After the fruiting bodies have attained their final shape and size they become light, brownish-lavender in color; from this they gradually change until the blue-gray color of mature sporangia is attained. In most fruitings the white hypothallus typical of the species is present. Mature sporangia are shown in Fig. 11. In a few cultures plasmodia became pale lavender three or four days before fruiting bodies were formed, but in most cultures there was no color change until after sporangial delimitation was apparent.

Viable sclerotia of *P. didermoides* were obtained by removing the covers from petri dish cultures of actively growing plasmodia and allowing the plasmodia and agar substrate to dry slowly. Upon being moistened such sclerotia revived and streaming could be observed in about twenty-four hours. As in the preceding species, spores from sporangia which developed in culture were found to be viable.

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THE ROLE OF THE SUBEPIDERMAL NERVOUS SYSTEM IN THE LOCOMOTION OF THE EARTHWORM

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The Ohio State University

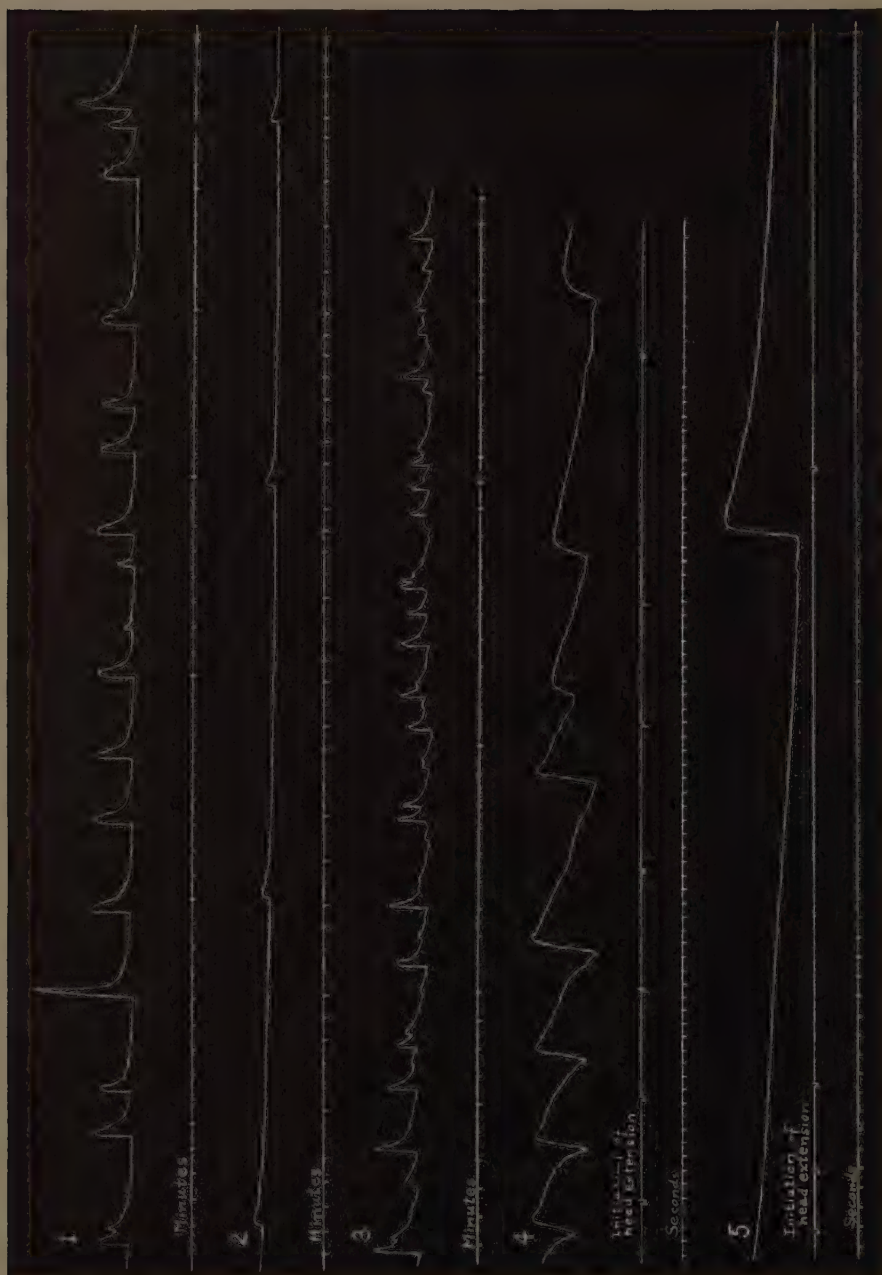
Friedländer (1894) was the first one to show that the central nervous system plays only a small part in the creeping movement of an earthworm. He concluded that the wave-like motion of the contractions proceeding the length of the worm was due first to the "pull" of segments on each other, and secondly to the sequence of reflex actions in each segment. This nervous mechanism, according to Friedländer, involves the individual segment alone without the passage of impulses through the cord. Biedermann ('04) found that when the middle region of a worm was anaesthetized, the posterior region acted in perfect coordination with the anterior part in creeping movements. In another experiment he observed that when the anaesthetized region was pinned to a cork plate, the posterior part still moved in perfect coordination with the anterior part. Thus, he demonstrated the transmission of impulses over considerable distance in the cord. Garry and Moore ('15) studied the coordination of the peristaltic waves. They verified the work of Biedermann to the extent that the peristaltic impulses are conducted by the cord. Straub (1900) observed that strips of body wall both with and without ventral nerve cord will give rhythmic contractions. However, the strips removed from denervated regions required several (eight) days for recuperation before such strips could produce rhythmic contractions. Budington ('02) found that when care was used to remove all nervous tissue and used only pieces of worm in which the whole ventral muscle had been removed they failed to demonstrate rhythmic contraction. An extensive study of the transmission of the nervous impulses in relation to locomotion was made by Bovard ('18). He showed that after the cord was cut at the middle region of the body, both ends would not act in perfect coordination. He disagreed with Straub's (1900) finding that a piece of the body wall without nerve cord is able to make rhythmic contraction.

On the other hand the presence of a subepidermal network of nerves was observed by Retzius (1892), Smirnow (1894), Langdon (1895), and Smallwood ('23, '26) and was carefully studied morphologically by Hess ('25). Hess found that the subepidermal network of nerves in the earthworm is a true nerve plexus composed of anastomosing nerve fibers which form a network in the region between the bases of the epidermal cells and the basement membrane. He concluded that this plexus is not segmental in its arrangement. Coonfield ('32) disagrees with Hess and Smallwood regarding the continuous nature of the plexus. His experiments on the secretion of mucous and the discharge of coelomic fluid show that impulses are not transmitted from somite to somite without the presence of the ventral nerve cord. He concluded that the peripheral nervous system is not a continuous nerve net.

Because of these controversies of opinions, it is the purpose of this paper to present the results obtained from further investigations employing physiological methods. The earthworm used in the following experiments is *Lumbricus terrestris*, found in Columbus, Ohio. The room temperature during the experiments was 26-27° C.

BEHAVIOR FOLLOWING REMOVAL OF VENTRAL NERVE CORD

Sections consisting of 40-60 segments exclusive of the head were cut from healthy unanaesthetized worms. Following the removal of the intestine in saline



solution, the body wall was turned inside out and the ventral nerve cord was completely removed with the aid of the binocular microscope. The body wall was then reversed (skin side out) and placed in a Petri dish containing normal saline Solution. It was seen under the binocular microscope that this operated section exhibited only slight constriction movements. When these movements were watched carefully, we could see that each was confined to an individual segment and was independent of the remaining segments. After one to two hours, the above described involuntary movements ceased to occur. The section as a whole, however, was more sensitive to touch. If such a section was touched or pinched, a wave of longitudinal muscle contraction could be initiated at any segment and could move in either or both directions. The sequence of contraction was segment to segment. Measuring with a stop watch, it was determined that the rate of contraction wave varied from 3.0 segments per second to 4.3 segments per second. The average rate was 3.8 segments per second. The distance traveled by the contraction wave in the pieces tested varied from 11-43 segments. Stimulation of a section in the middle would initiate waves of contraction in both directions. The speed of the contractions thus initiated was the same in both directions. The contraction of the circular muscle was not observed when the body wall was pinched or touched.

Each operated section was then attached to a recording lever. The section was so placed that it hung vertically with only very slight stretching by the lever. The whole piece was kept submerged in normal saline solution and the contractions were recorded in a slowly moving kymograph drum. It was found that of the many pieces tested, some of them recorded autonomic contractions during the first few hours after their preparation (see figure 1). Those sections which did not give immediate contractions were kept in refrigeration at 5°C for a day and then were allowed to stay at room temperature for a few hours before they were tested again. It is shown in the kymograph record (see figure 3) that active autonomous contractions of shorter intervals were initiated by such treatments.

However, both the magnitude and rhythm of contractions of a single piece or of the different pieces varied a great deal. It was observed that the magnitude of the contractions depends in part upon the total length of the section and the vitality of the piece tested. It is also related to the distance of the contraction waves traveled, i.e., the farther the waves travel, the greater will be the magnitude, because of the fact that the relaxation phase is much shorter than the contraction phase as the contraction waves travel along each of the successive somites. As to the rhythm, the intervals of contraction were irregular, varying from two to five minutes.

In order to determine whether the magnitude or the interval of contractions in a given section could be changed by splitting, a previously tested section was split longitudinally along the middorsal line. It was observed that immediately after splitting, the length of the section became much shorter. A section thus

EXPLANATION OF PLATE I

FIGURE 1. The rhythm of contractions of a section (42 segments) whose nerve cord has been completely removed.

FIGURE 2. The decrease of frequency and magnitude of contractions following a longitudinal split along the middorsal line. (The same section used in the illustration Figure 1.)

FIGURE 3. Showing the occurrence of contractions of a section (40 segments) which has been kept in refrigeration for a day.

FIGURE 4. Illustrating the coordinated movement of the tail after each extension of the head when ten segments of the middle region of the body were fixed by pinning. Each peak represents maximum contraction.

FIGURE 5. Demonstrating that no coordinated movement of the tail took place when the nerve cord was cut in the fixed region.

operated lengthened in time but never regained its initial length. The magnitude of contractions of such operated pieces diminished while the interval of contractions increased (see figure 2). This is interpreted as the result of the loss of tone of the circular muscle layer.

DISTANCE OF IMPULSE TRANSMISSION THROUGH THE SUBEPIDERMAL NERVOUS SYSTEM

An unanaesthetized worm was split longitudinally along the middorsal line for a distance of ten segments in the midbody region. The intestine was removed from this region exposing the ventral nerve cord. The operated portion was then fixed firmly in a dissecting tray with small-sized insect pins (about three to four pins on each segment). The pinning process was done under the dissecting microscope to avoid injury to the segmental nerves. Both the anterior and posterior regions were free to move. Only the posterior tip was connected to the recording lever. The initiation of each extension of the head was marked by a signal magnet. The record (figure 4) shows that the impulses from the head region could be transmitted through the fixed middle region to the tail in an average of four seconds when the ventral nerve cord was intact. When the nerve cord was severed between the seventh and eighth segment of the fixed operated region without injury to the lateral nerves, there was no movement of the tail following head extension in this experiment (figure 5). It was necessary that the nerve cord be cut near the caudal margin of the exposed area in order that all "pull" produced by the unattached anterior region would be eliminated. Furthermore, movement of the tail region could not be induced by applying Faradic shocks to the cord in the head region. This clearly shows that the subepidermal nervous system cannot transmit locomotor impulses from one segment to the next if the segments are prevented from movement. The experimental evidence further substantiates the contention that the subepidermal nervous system is segmental in arrangement.

DISCUSSION

The occurrence of irregular contractions of a section lacking the ventral nerve cord is worthy of discussion. These experiments have been repeated several times and constant results obtained. It is also necessary to mention here that extreme care was taken to eliminate the entire ventral nerve cord. It has been shown that when the body wall was split longitudinally, the tone of the circular muscle layer was diminished, and the whole piece became shorter in length. As a result both the frequency and magnitude of contractions decreased. That Budington ('02) and Bovard's ('18) isolated strips could not produce contraction might be due to the loss of tone of the circular and longitudinal muscles. In addition, sufficient time for recovery from operative shock or injury due to overstretching was necessary. At all times the section should be kept in a saline solution bath even though attached to the recording lever. In addition to the above requirements, the writers have found that a slight stretching of the section by the recording lever may be an important factor in initiating contraction. Such contraction waves were not observed when the section was laid unattached in normal saline solution. Zyeng ('30) has found that there are nerve cells located between longitudinal and circular muscles, between the epidermis and the circular muscle layer and sometimes within the circular muscle layer itself. The presence of these cell bodies may account for the autonomic movement of the isolated piece in the absence of the ventral nerve cord.

Bovard ('18) in interpreting the rhythmic contractions described by Straub suggested that such phenomenon may be due to the regeneration of nerve fibers and cells. However, according to our observations, such contractions occurred either shortly after the operation or within twenty-four hours after recovery under

refrigeration. This strongly suggests that regeneration is not a factor in explaining this phenomenon.

The results obtained by the writers using completely different physiological methods from those previously employed are in agreement with Coonfield's ('32) findings concerning the segmental arrangement of the subepidermal nervous system in the earthworm. The impulses which are transmitted from segment to segment are not through the "subepidermal nerve net" but are conveyed through the peripheral nerves and ventral nerve cord. In locomotion, impulses are initiated in successive segments by the pulling action of the adjacent segments.

According to the writers' observations, the most probable functions of the subepidermal nervous system are the regulation of the contraction of the longitudinal muscle and, as a reinforcement of locomotor impulses. Bovard ('18) found that the locomotor impulses travel short distances of ten segments very readily, and more difficultly as the number of segments increases; but, impulses are unable to pass through a distance of thirty segments unless there is reinforcement from the muscle. Let us make some mathematical calculations based on Bovard's and the writers' data to see whether our conclusion concerning the function of the subepidermal nervous system as a reinforcing mechanism can fit the actual situation. The rate of the peristaltic waves of the earthworm under the conditions tested was found by the writers to be about 3 cm. per second. If a worm is 14 cm. long, it will take 4.7 seconds for a contraction wave to travel from the head to the tail. The time consumed in this reaction far exceeds the time required for actual impulse transmission. But if we assume that in every ten segments a reinforcement takes place, then there will be fourteen reinforcements. As found in one of the previous experiments, the rate of contraction wave in the body wall in absence of the nerve cord is approximately 3.8 segments per second (1 segment per 0.26 second). For fourteen reinforcements, it will take about 3.6 seconds which is $\frac{3}{4}$ of the total time needed for the propagation of the wave, and only 1.1 second is left for the transmission of the impulses through the nerve cord and the delay in the various synapses. The synapses involved include those in the ventral nerve cord and those between the segmental nerve endings and the subepidermal neurons. It seems that this shorter time fits better the faster conduction rate of the nerve impulses occurring in the central nervous system.

The activity of the isolated section from which the ventral nerve cord was removed shows that the circular and longitudinal muscles are governed by two different sets of nerves. Stimulation of the epidermis results in the contraction of only the longitudinal muscle. The contraction of the circular muscle should therefore be controlled by the central nervous system. This interpretation seems to fit very well with the mechanism of locomotion. As we know, when a worm begins to move forward, the circular muscle of the head region contracts first. The initiation of the contraction of the circular muscle is due to impulses from the central nervous system. The contraction of the circular muscle in turn stretches the longitudinal muscle. As a result, reinforcing impulses are sent into the central nervous system, and at the same time, a contraction of the longitudinal muscle is initiated.

SUMMARY

1. In the absence of the ventral nerve cord, impulses can be initiated in the body wall and transmitted in both directions.
2. The initiation of such impulses can be accomplished by mechanical stimulation.
3. The impulses initiated in such a denervated section are conducted within the limits of a single segment through the subepidermal nerve net. Such impulses originate in successive segments as a result of the pulling action of the adjacent segments.

4. The contraction wave is 3.8 segments per second of a section without a ventral nerve cord.
5. The subepidermal nervous system of the earthworm is shown through physiological analyses to be segmental in arrangement.
6. The most probable role of the subepidermal nervous system is that of controlling the contraction of the longitudinal muscle and acting as a reinforcing agent in the peristaltic waves.

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NEW EASTERN SPECIES AND A NEWLY REPORTED
INTRODUCTION OF TYPHLOCYBA
(HOMOPTERA, CICADELLIDAE)

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AND

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During the procedure of identification of material in the genus *Typhlocyba* in the course of preparation of the second part of the "Leafhoppers of Illinois," a few interesting new species have been encountered which are described in this paper. To aid in comparison, illustrations of two other species are added.

The species of *Typhlocyba* have previously been grouped by McAtee¹ on the basis of differences in wing venation. The variation of the venation in individuals is sufficient, however, to frequently warrant the placing of individuals of the same species in different groups as defined by McAtee. It would appear that it will be necessary eventually to group the species of the genus on the basis of male genital characters rather than upon the basis of wing venation. No attempt has been made, therefore, in describing these species to place them in the groups established on the basis of wing venation.

We wish to thank Dr. R. H. Beamer for his opinions concerning certain of the species, and Dr. P. W. Oman who has very kindly compared material and drawings of *eurydice* with McAtee's type which is now in the U. S. National Museum.

In the interests of clearer description, it has seemed advisable to introduce an additional term with regard to the aedeagus, a term which will be found useful throughout the Cicadellinae. The aedeagus is divided into three fairly distinct parts, the base (*socle* of Ribaut), which is the part actually set in the membrane which connects the aedeagus to surrounding body members; a freely projecting portion usually termed the "free part of the aedeagus" or some equivalent phrase, and for this part we propose the term *phallicata*; and various style-like processes arising from the base itself or from the area where the phallicata joins the base. These latter processes have been called ventral processes, appendages of the aedeagus, and other phrases; for these it seems very convenient to use the term processes, which can be modified by various adjectives to indicate numbers and positions.

Unless otherwise specified, types described in this paper are in the collection of the Illinois Natural History Survey.

Typhlocyba tortosa new species

This species appears most closely related to *cassiopeia* Knull, but differs from it radically in the shape of the pygofer and the shape of the phallicata, which in *cassiopeia* has a pair of very long lateral processes and a large mesal lobe, but in *tortosa*, fig. 1, has the apex divided into a pair of quite short lateral processes with no appreciable mesal lobe. Length male 3 mm.

Color, white without markings.

Male pygofer broad at apex with a slight indication of a spine on the dorsal caudal margin. The aedeagus in lateral view has a phallicata which is gradually tapered to a slender attenuated apex. In ventro-caudal view the phallicata is elongate, rather uniform in width to the apical

¹Revision of the American Leaf Hoppers of the Jassid Genus *Typhlocyba*. Proc. U. S. N. M. 68: 1-47, 6 pl. 1926.

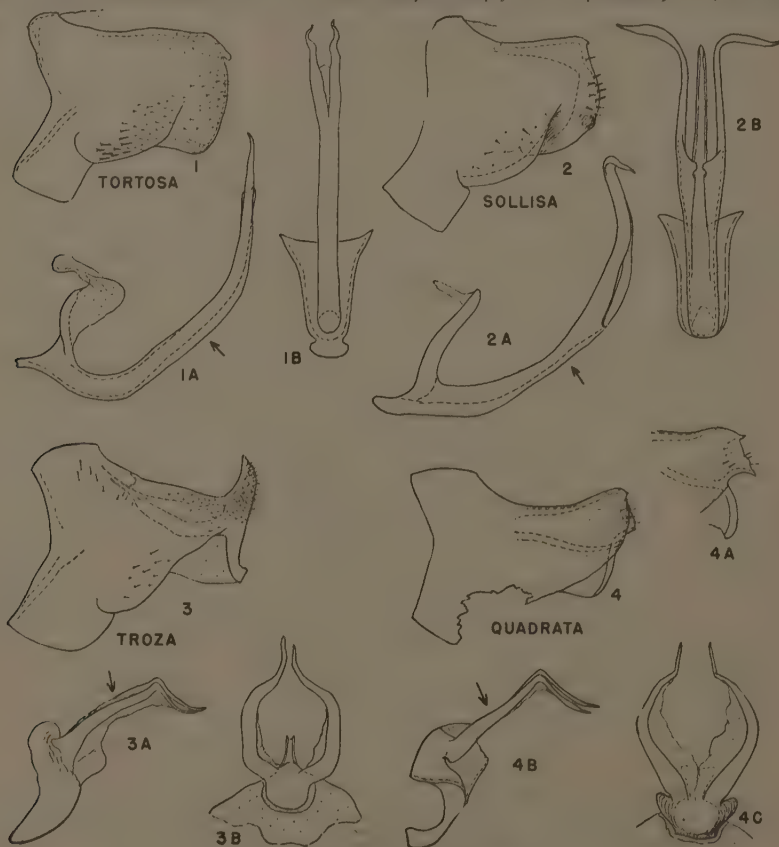
portion which is divided on the apical fourth, forming a pair of somewhat divergent, tapered, pointed apical processes.

Holotype, male—Oakwood, Illinois, June 14, 1936, C. O. Mohr.

***Typhlocyba sollisa* new species**

This species is most closely related to *pulmani* Knoll, differing in having the phallicata subdivided less than half way to its base in forming the mesal and pair of lateral processes, fig. 2. The lateral processes are also curved to nearly a right angle and the base of the aedeagus is narrow in lateral view. Length male 3.5 mm.

Color, pale yellow, with paler areas on vertex, pronotum and scutellum. The wings darker yellow subhyaline to the cross veins. The veins conspicuously yellow. Apex subhyaline, not tinted.



Male Genitalia of *Typhlocyba*

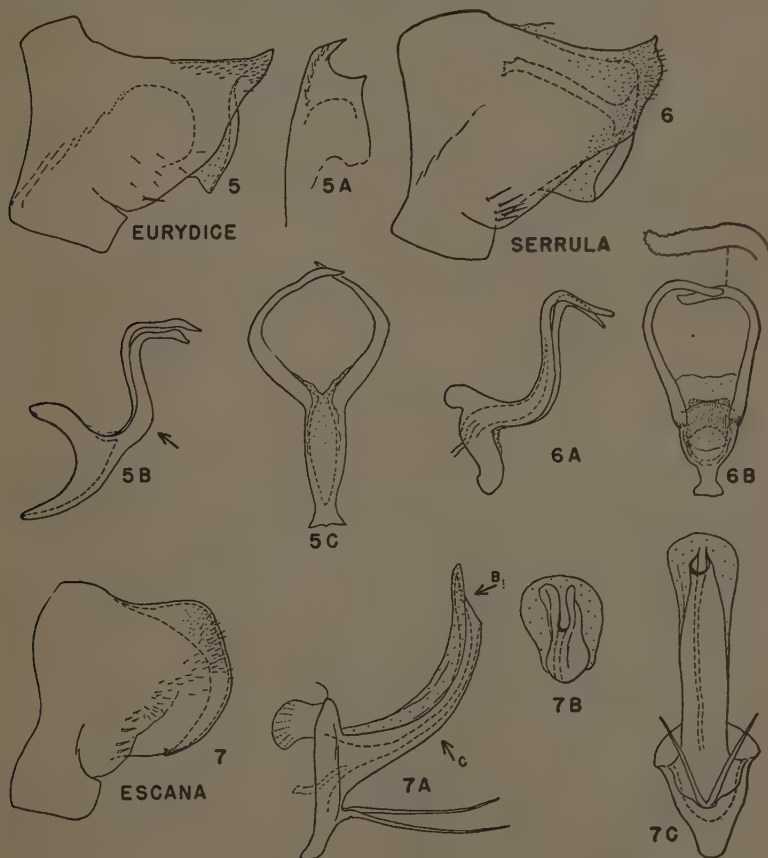
FIG. 1. *T. tortosa* n. sp., pygofer, lateral aspect; 1A, aedeagus, lateral aspect; 1B, aedeagus, posteroventral aspect from direction of arrow in 1A. FIG. 2. *T. sollisa* n. sp., pygofer, lateral aspect; 2A, aedeagus, lateral aspect; 2B, aedeagus, posteroventral aspect from direction of arrow in 2A. FIG. 3. *T. troza* n. sp., pygofer, lateral aspect; 3A, aedeagus, lateral aspect; 3B, aedeagus, dorsal aspect from direction of arrow in 3A. FIG. 4. *T. quadrata* D. & J., pygofer, lateral aspect; 4A, tip of pygofer, posterolateral aspect; 4B, aedeagus, lateral aspect; 4C, aedeagus, dorsal aspect from direction of arrow in 4B.

Male pygofer rather broad at apex without apical spine. Aedeagus with the phallicata divided at more than half its length to form three processes, a slender mesal process and a pair of lateral processes which are slender, rather widely separated, extending apically almost parallel to near apices which are divergent and curved apically.

Holotype, male—Grand Tower, Illinois, May 30, 1935, Ross and Mohr.

Typhlocyba troza new species

The curious shape of the aedeagus indicates a very close relationship between this species and *quadrata* D. & J., but the two differ markedly in characters of the pygofer. In *troza* this structure ends in a long vertical sharp projection which continues ventrad into a stout arm,



Male Genitalia of *Typhlocyba*

FIG. 5. *T. eurydice* McAtee, pygofer, lateral aspect; 5A, pygofer, posterior aspect; 5B, aedeagus, lateral aspect; 5C, aedeagus, posteroventral aspect from direction of arrow in 5B. FIG. 6. *T. serrula* n. sp., pygofer, lateral aspect; 6A, aedeagus, lateral aspect; 6B, aedeagus, posterolateral aspect, same orientation as for 5C. FIG. 7. *T. escana* n. sp., pygofer, lateral aspect; 7A, aedeagus, lateral aspect; 7B, phallicata from direction of arrow B in 7A; 7C, aedeagus, ventral aspect from direction of arrow C in 7A.

In Figs. 1-7 illustrations of the aedeagus are 1.5 times the magnification of the pygofer.

Fig. 3; in *quadrata* the pygofer has no such projection, but instead curves mesad and forms an irregularly and obliquely truncate lobe, Figs. 4, 4A. The two differ also in details of the aedeagus. In *troza* the dorsal part of the base of this structure is narrow and the lateral arms form an almost rectangular enclosure, Figs. 3A, 3B; in *quadrata* the dorsal part of the base extends laterally beyond the base of the arms, and the lateral arms themselves are more parenthesis-shaped. In both species it is difficult to identify the phallicata with certainty, but it appears to be a membranous projection arising between and beneath the large lateral arms. Length 3.5 mm.

The vertex is strongly produced and somewhat conical.

Color, white strongly tinted with yellow on the vertex, pronotum and scutellum. Wings distinctly yellow, subhyaline, a broken brownish band composed of four spots just before the cross nervures anterior to the apical cells.

Holotype, male—Karnak, Illinois, June 14, 1934, DeLong and Ross.

Typhlocyba serrula new species

This species is most closely related to *eurydice* McAtee, from which it differs in characters of the pygofer and aedeagus. The pygofer is pointed, Fig. 6, somewhat as in *eurydice*, Fig. 5, but lacks the mesal flap with its sharp dorsal point which is characteristic of *eurydice*, Fig. 5A. In *serrula* the aedeagus is much more sharply sinuate in lateral view, Fig. 6A, and has longer arms and a shorter base in postero-ventral view, Fig. 6B. Length 4 mm.

Color, white without markings, wings white subhyaline.

The aedeagus in postero-ventral view has a shorter basal portion, the arms are longer, more widely separated at the base, and the apices are thicker and more blunt than in *eurydice*.

The female sternite is roundedly produced.

Holotype, male, allotype female and female paratypes—Waynesburg, Pennsylvania, July 17, 1919, D. M. DeLong. Male paratype—N. Bloomfield, Pa., July 16, 1920, J. G. Sanders. Holotype, allotype and paratypes in DeLong collection, paratype in Illinois Natural History Survey collection.

Typhlocyba escana new species

In characteristics of pygofer and style this species belongs to the *rubriocellata* group but differs from *rubriocellata* and related species in the undivided long curved phallicata and the pair of slender ventral processes, Figs. 7A, 7B, 7C. Length, male 4 mm.

Color, white, scutellum embrowned. Wings white, the claval area unmarked, apical portion smoky, intensified anteriorly to form a broad brownish band across the cross nervures. A transverse yellowish band is just anterior to the brownish portion. There is a reddish area on the median basal half of the wing just anterior to the clavus. The costal margin is white.

Male pygofer broad at apex. The aedeagus phallicata in lateral view is rather broad, curved dorsally and tapered to a narrow apex. The postero-ventral portion is convexly inflated, not reaching the apex of the anterior portion and open at the middle at apex. There is a pair of rather long slender processes which arise below the phallicata at base and extend caudally.

Holotype, male—Alum cave parking area, Great Smoky Mountains National Park, Tennessee, August 31, 1948, on *Aesculus*, Ross and Stannard. Allotype female—Chimneys Camp Ground, Great Smoky Mountains National Park, Tennessee, August 30, 1948, on *Aesculus*. Paratypes—Same data as for holotype, 1 male; same data as for allotype, 2 females.

Typhlocyba quercus (Fabricius)

A series of this palearectic species was taken in western British Columbia on Queen Anne cherry, and apparently constitutes a new record for North America. The data of collection are Vancouver, B. C., July 15, 1946, H. H. Ross.

This pretty species is brightly colored with a mottled red pattern, and superficially looks very much like some of the showy members of the *Comes* group of *Erythroneura*. The short style, elongate and cylindrical phallicata, and the long twisted ventral processes of the aedeagus distinguish this species from any North American members of the genus. These characters have been illustrated in detail by Ribaut 1936 (Faune De France 31:123, figs. 317-323). We are indebted to Dr. Ohman for confirming the identification of this new introduction. The species is recorded in Europe on oak, plum, cherry, and other hosts.

NEW LEAFHOPPERS FROM THE UNITED STATES (HOMOPTERA: CICADELLIDAE)¹

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Stragania (*Penestrangania*) *hualpaiana* n. sp.

Resembling *S. robusta* (Uhler) but with a distinctly swollen produced head and elytra more thickly set with short black setae.

Vertex swollen, roundedly produced over half its length before eyes, narrower than pronotum, twice as long as vertex; elytra thickly set with evenly spaced very short black setae arising from small brown round spots over entire elytra, except appendices. Pronotum transversely striate.

Color pea green, veins and feet brighter blue green; head pronotum and scutellum washed with golden yellow, elytra greenish semihyaline.

Genitalia: Posterior margin of ♀ last ventral segment excavated slightly from lateral angles and very slightly produced at middle, entire. Pygofer of ♂ with large hook bent in at almost a right angle at middle, tapered on outer fifth from hump on inside to sharp point; styles small, inner margins straight, outer margins curved gently from base, broadest before middle, tapering to apices which turn out abruptly and are sharptipped. Aedeagus as in *S. robusta* (Uhler).

Length: ♂, 4.5 mm.; ♀, 5 mm.

Holotype ♂, *allotype*, 18 ♂ *paratypes* and 29 ♀ *paratypes*, Hualpai Mts., Arizona, June 2, 1948; 3 ♀ *paratypes*, July 4, 1937, collected by D. J. & J. N. Knull, and placed in collection of The Ohio State University.

The three ♀ specimens taken in 1937 were sent to Dr. Beamer some time ago. He marked them "*S. (Penestrangania)* sp.—need ♂s." The series taken in 1948 included ♂s and proved to be an undescribed species.

Stirellus subnubilus n. sp.

A dark-winged species with pale, conical head.

Head as wide as pronotum; vertex slightly less than one-third longer at middle than width between eyes; less than twice as long at middle as next to eyes, eyes large. Pronotum $2\frac{3}{4}$ times as wide as long, length at middle about $\frac{1}{4}$ shorter than vertex; lateral margins very short, humeral margins long, posterior margin very slightly emarginate, disc irregularly wrinkled, margins, scutellum and vertex finely granulate. Elytra exceeding apex of abdomen in ♂, slightly exceeded by ovipositor in ♀.

Color. Vertex pale, a pair of large black discal spots, rather square; another pair on basal disc, elongate dashes; eyes gray. Pronotum dark brown on disc, darker at margins, with some yellow irregular spots along anterior margin. Scutellum with basal angles, median square between them, and apical triangle black, separated by narrow yellow lines and margins. Elytra dark brown, veins a little darker, especially apically, appendix and apical cells somewhat paler, semihyaline. Below, face and antennae pale, remnants of six short dark arcs either side, a line below clypeal suture and apical two-thirds of clypeus dark, also lower half of lorae, antennal socket area, and region bordering eyes. Venter and dorsum dark, segments narrowly yellow-margined, apex of pygofer in male pale; legs dark with pale spines; ♀, legs paler, ovipositor, basal area and spines of pygofer pale.

Genitalia. Female last ventral segment as long as preceding, evenly, faintly emarginate from rounded sides to middle; ovipositor exceeding pygofer by about twice its greatest width, its apex set with fine white hairs, about 7 long pale spines either side on pygofers; males with triangular valve, produced apically in a sharp pale spine; plates twice as long and broad as valve (without spine), together forming semicircle; outer submargin of each set with six long pale

¹The author acknowledges with gratitude payment for plates by grant from the Ohio Academy of Science Research Fund.

spines, evenly spaced; pygofer extends a third below plates, truncate, pale, swollen inner apical angles conspicuous.

Length: ♂, 2.8 mm.; ♀, 3.5 mm.

Described from specimens taken in Mississippi in 1922 by Herbert Osborn, in the Osborn Collection, The Ohio State University.

♂ *holotype*, Ocean Springs, Febr. 25; *allotype* and 1 ♂ *paratype*, Febr. 2; 2 ♀ and 1 ♂ *paratypes*, Hurley, Febr. 25; 1 ♀ *paratype*, Wade, Febr. 24.

In form this species is closest to *Stirellus dixianus* var. *acutus* Thomas, but the coloring is very distinct.

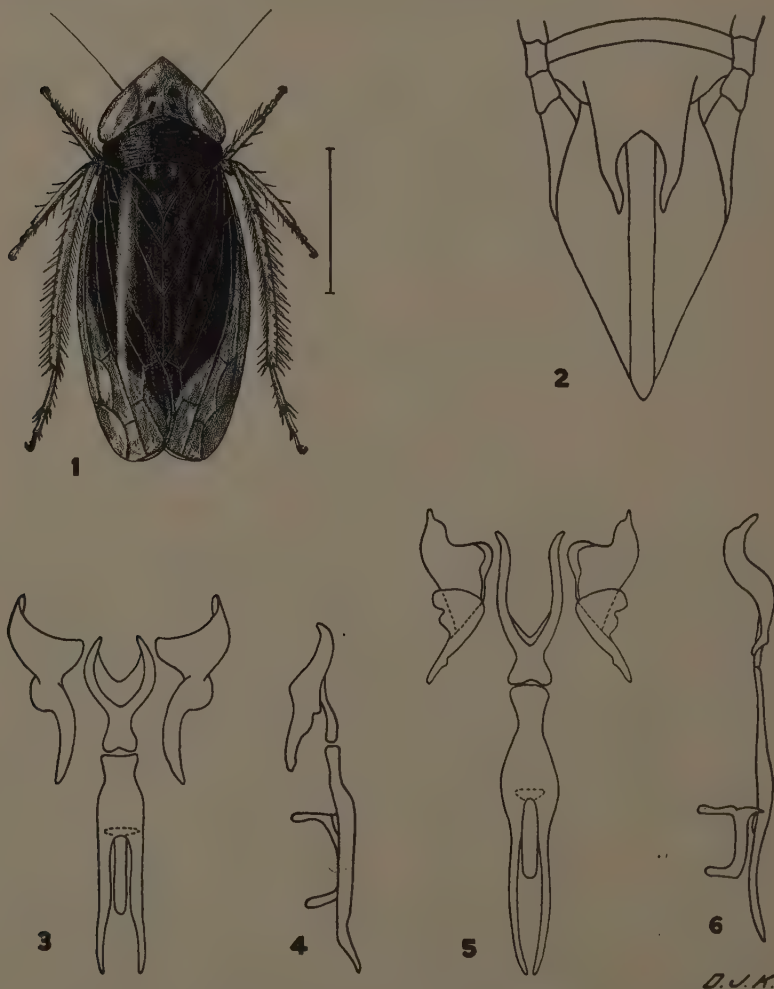


FIG. 1. *Stirellus nubilus* Knull—line = 1 mm. FIG. 2. *Spathanus excavatus* Knull—ventral view of ♀ abdomen. 3. *Spathanus aureus* Knull—ventral view inner ♂ genitalia. FIG. 4. *Spathanus aureus* Knull—lateral view inner ♂ genitalia. FIG. 5. *Spathanus acutus* Knull—ventral view inner ♂ genitalia. FIG. 6. *Spathanus acutus* Knull—lateral view inner ♂ genitalia.

Three species are described in the tightly knit genus *Spathanus*, two from California and one from Nevada. Creosote bush (*Larrea tridentata* var. *glutinosa* Jepson) is a food plant of all species known. All specimens are placed in the collection of The Ohio State University.

***Spathanus mirus* (Van Duzee)**

Scaphoideus mirus Van Duzee, Proc. Calif. Acad. Sciences, 14:419-20, 1925.

Osbornellus mirus (Van Duzee), DeLong & Knull, Check List of Cicadellidae, Grad. Studies, The Ohio State University Press, 1:32, 1945.

Spathanus acuminatus (Baker), Oman, Jour. N. Y. Ent. Soc. 55:61, 1947.

I am indebted to Dr. P. W. Oman and Dr. Edward S. Ross for their help in determining the status of *Spathanus mirus* (Van Duzee). My study of specimens along with their comments, and Dr. Ross's notes on the type, convince me that *S. mirus* is a valid species.

*** *Spathanus acutus* n. sp.**

Immediately distinguished by pale vertex, pronotum, scutellum and basal third of clavus in distinct contrast to darker remainder of elytra. In ♂ plates are longer than in *acuminatus*, attenuate apices almost reaching apex of pygofer.

♂. Vertex roundedly produced, one-third broader at base than median length; pronotum longer than vertex, hind margin almost straight; elytra considerably longer than abdomen, apices rounded, apical cells short.

Color. Vertex golden, median longitudinal impressed black line from base two-thirds distance to apex; eyes dark brown, front dark with about eight pale arcs either side, dark coloring of front showing a little from above; pronotum sordid yellow, more golden anteriorly, with some irregular translucent mottling; scutellum yellow, basal angles gray, transverse black impressed line before apex; elytra milky white on basal third, below marked with fuscous veins and cells of corium, apical and antenpical cells with discal round pale spots surrounded irregularly with dark brown, posterior two-thirds of clavus dark brown with two oval pale spots along suture. Below brown, dorsum darker.

Last ventral segment of ♀ about length of preceding, lateral angles incised half their length next to broad produced median process, a little wider than a third, narrowed only gently toward apex which is shallowly roundly excavated between two sharp teeth; this process extends from base of segment one-half length of ovipositor, shorter than in *acuminatus*.

♂ plates long, triangular, attenuate on apical third, almost attaining apex of pygofer; styles short, broad at base, narrowed and produced on inner angle in small narrow apex shaped like a toe-dancer's foot, the toe pointed down and out. Aedeagus with pair of long slender, straight processes narrowed to sharp incurved apices, exceeding attenuate plate tips in length; dorsal portion gently curved, attached near separation point of ventral processes with a short arm, tube extending two-thirds length of processes, turned dorsad at apex about as far as basal arm. In lateral view ventral aedeagus slightly sinuate, broad at base, blades narrow.

Length: ♂, 4.5 mm.; ♀, 4.75 mm.

Described from specimens taken from creosote bush by D. J. & J. N. Knull. ♂ holotype, Santa Rosa Mts. (Dos Palms), Riverside Co., Calif., June 15, 1946; 1 ♂ and 1 ♀ paratype, same locality, June 15, 1948; 3 ♀s, allotype and paratypes, Palm Springs, Riverside Co., Calif., June 30, 1946; 1 ♂ paratype, June 15, 1948.

***Spathanus aureus* n. sp.**

Above and below golden brown in color with markings faint but similar to those of *acuminatus*.

♂. Plates long, triangular, attenuate, apical third not quite as long as pygofer, dark oblique dash on disc; styles heavy, inner angle produced in a long heavy blade curved out, blade almost as long as basal portion; aedeagus shorter and stouter than in *acutus* and *acuminatus*, ventral paired processes slightly sinuate, narrowed on apical half, apices dark, sharp; aedeagus shallowly U-shaped; in lateral view apices of ventral arms turned ventrad. Styles are unique character.

♀. Segment as in *acutus*, concave, a little shorter, apex narrowed more abruptly.

Length: ♂ 4.75 mm.; ♀, 5 mm.

♂ holotype Shavers Well, Calif., Riverside Co., June 17, 1946; allotype and 1 ♂ paratype same data; 1 ♂ and 1 ♀ paratype, Yuma, Arizona, June 11, 1937; 1 ♂ paratype, Morongo Valley, Calif., Riverside Co., June 5, 1946. Collected by D. J. & J. N. Knull.

Spathanus excavatus n. sp.

♀. Short, robust, pale golden brown, veins of apices of elytra darker, five reflex veinlets on costa outside outer anteapical cell.

Last ventral segment with lateral lobes one-third longer than preceding, rounded, incised one-half length next to median process; process twice as long as broad, occupying median half of segment, tapered gradually from base, apex deeply excavated half way to base, leaving two comparatively slender points which approach one another at their apices; median projection from base less than half length of pygofer.

Length: ♀, 4.5 mm.

Described from 1 ♀ holotype, Las Vegas, Nev., June 30, 1937, D. J. & J. N. Knull.

The last segment of the ♀ places this nearer to *S. mirus* (V. D.) than to other members of the genus, but it is shorter, paler and more robust than *mirus*.

Erythroneura flexibilis n. sp.

General ground color semihyaline to white tinged with yellow anteriorly, marked with bright red. Vertex with short red transverse rectangle at apex, two basal oval pale spots surrounded except at base by irregular red markings which join at middle. Pronotum with median heart-shaped spot and an irregular spot behind either eye. Scutellum with tip red and basal angles yellow narrowly red outlined. Clavus with broad basal anchor-shaped spot and one before apex. Corium with angulate mark arising on costa before humeral angle, another irregular and broken angulate vitta arising on costa at anterior end of plaque, more or less surrounding it and ending on mesal margin near tip of clavus in an enlarged area. Crossveins and adjacent longitudinal veins red, apices of elytra smoky. Large black spot in base of cell M₄. Below with spot before apex of vertex, area above antennae, face before clypeus and posterior tibiae red, remainder stramineous.

♂ genitalia. Pygofer hook single, of medium length, turned in on outer third, sharp-pointed. Style with small foot, base curved, heel about a right angle, anterior point less than right angle, projecting outward; posterior point very slightly longer than base of foot, fine, sharp, meeting base at less than right angle. Aedeagus of medium length, straight, in ventral view with lateral rough teeth, in lateral view with truncate tip.

Length: 3 mm.

♂ holotype, Delaware Co., Ohio, March 18, 1945; ♂ paratypes, Delaware Co., O., 1 March 18, 1945, 1 March 25, 1945, 1 August 13, 1944; 3 Highland Co., O., June 6, 1945, all collected by D. J. and J. N. Knull; 2 Hartwick St. Park, Mich., July 19, Mary Auten; 1 Cranberry Lake, N. Y., August 9, 1920, Osborn & Drake (in the Osborn Collection, The Ohio State University).

Runs to *E. lorella* Rob. in Beamer's key² but differs in more abrupt turn in pygofer hook, size of aedeagus, and shape of style.

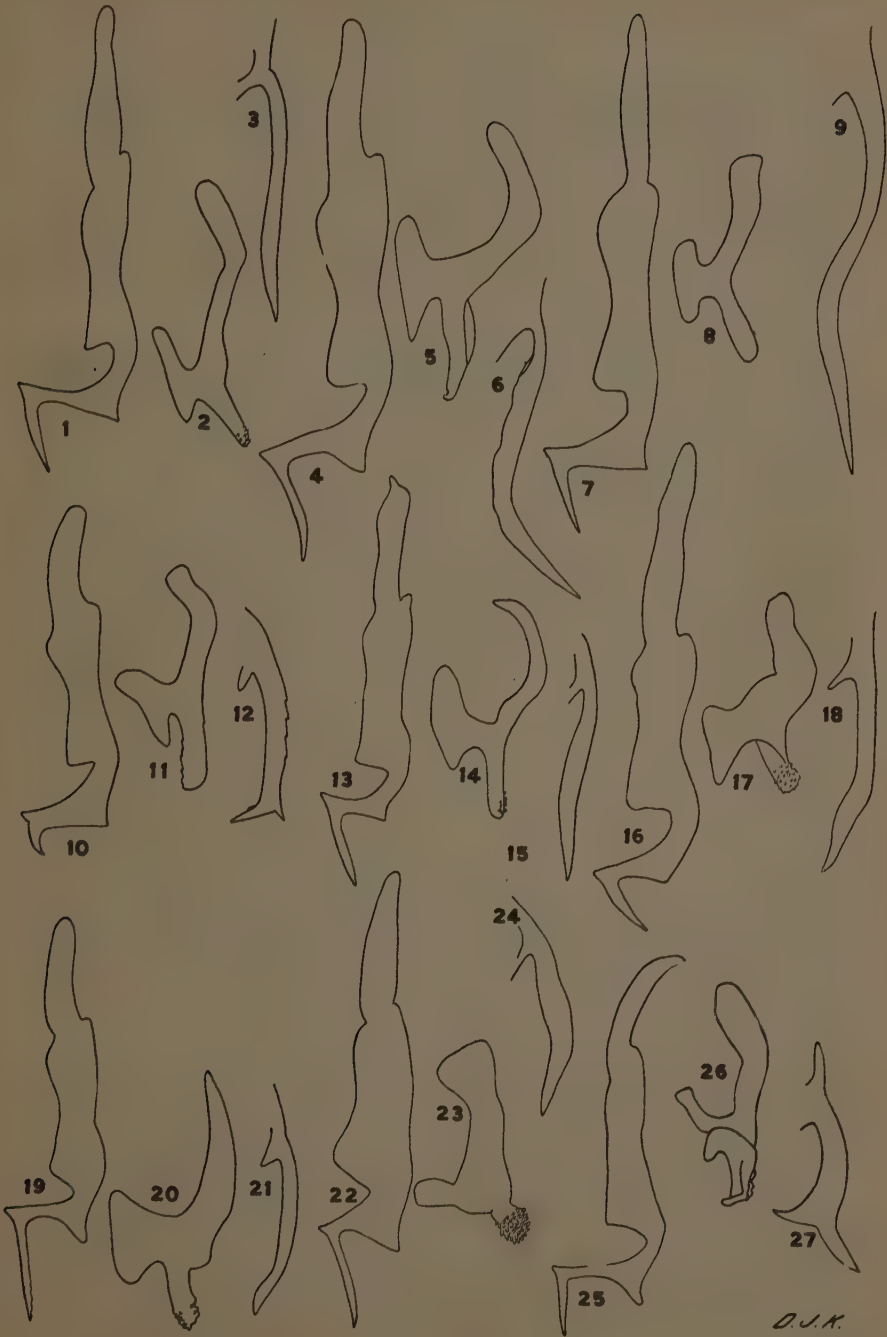
Erythroneura dimidiata n. sp.

Small, general round color semihyaline to yellowish white marked with orange. Vertex with five white spots narrowly bordered with orange. Pronotum with median Y-shaped mark not reaching either edge, angulate vitta behind either eye. Scutellum with red apex, yellow basal angles. Clavi with basal anchor-shaped spot, and one before tip; coria with spot on costa before base, irregular blotches surrounding three sides of costal plaque and spot below apex of clavus. Crossveins and adjacent longitudinal veins narrowly red. Faint black spot in base of cell M₄, tips of elytra faintly smoky. Venter white and stramineous with some pink tinges.

²R. H. Beamer, Can. Ent., 64: 174, 1932.

EXPLANATION OF PLATE II

Figs. 1, 2, 3. Style, aedeagus, pygofer hook, *Erythroneura malaca* Knull. Figs. 4, 5, 6. Style, aedeagus, pygofer hook, *Erythroneura hymettana* Knull. Figs. 7, 8, 9. Style, aedeagus, pygofer hook, *Erythroneura prolixa* Knull. Figs. 10, 11, 12. Style, aedeagus, pygofer hook, *Erythroneura uvaldeana* Knull. Figs. 13, 14, 15. Style, aedeagus, pygofer hook, *Erythroneura severini* Knull. Figs. 16, 17, 18. Style, aedeagus, pygofer hook, *Erythroneura flexibilis* Knull. Figs. 19, 20, 21. Style, aedeagus, pygofer hook, *Erythroneura direpta* Knull. Figs. 22, 23, 24. Style, aedeagus, pygofer hook, *Erythroneura luculenta* Knull. Figs. 25, 26, 27. Style, aedeagus, pygofer hook, *Erythroneura dimidiata* Knull.



D.J.K.

♂ *genitalia*. Pygofer hook single, curved in, with apex broadened and separated in diverging wings, outer a continuation of base, inner not quite as large and turned up, both sharp. Style with large thin foot, base straight, heel large, rectangular, anterior point about a right angle, posterior point about half length of foot, narrow, sharp, parallel-sided. Aedeagus of medium length, broad, with narrow transverse lip at apex.

Length: 2.5 mm.

Holotype ♂ from Hocking Co., Ohio, June 28; 3 ♂ *paratypes* taken in Hocking Co., Sept. 16, 1943, Sept. 14, 1944, and May 8, 1938 by D. J. & J. N. Knull. Types in collection of author.

This species runs to *E. californica* Beamer³ but resembles *E. minor* Beamer more closely in character of inner male genitalia.

Erythroneura hymettana n. sp.

Background white marked with red, brown and black. Vertex brown with elongate median spot pale, an apical red streak on either side of which is a small white spot. Pronotum tan, paler at posterior margin and darker in area surrounding three marginal anterior pale spots. Scutellum with basal angles tan and apex shining black, slightly raised as seen from side. Elytra with two red dots, one claval and one corial, at humeral angles, spots either end of costal plaque, elongate red streaks somewhat broken into dots in an oblique transverse band from plaque to apex of clavus, this band is parallel to one formed by red crossveins and adjacent longitudinal veins, between bands opaque white. A large quadrate gray-brown spot covering middle of clavus, another, large and just below it on corium, extending to costal plaque which is hyaline. Apices dark. Small black dot at base of cell M_4 and a dark streak at posterior end of plaque. Below stramineous, mesothorax dark, also dorsum of abdomen, and anterior margins of ventral abdominal segments; last ventral segment and apices of plates in male also dark with pale band between.

♂ *genitalia*. Pygofer hook longer than pygofer, ribbon-like, narrowed at base, broadening slightly, turning in a little at middle, then out on sharply pointed apical fourth. Style with large foot, base strongly curved, heel pointed down, less than a right angle; anterior point small and projecting out; posterior point longer than foot, tapering to sharp-pointed apex which turns out. Aedeagus long, narrow, broader at base and tapering to tip which is turned sharply dorsad in a small lip.

Length: 3.1 mm.

Described from 4 ♂ specimens collected by D. J. & J. N. Knull, 2 from Hocking Co., O., holotype, April 11, 1945, paratype, Sept. 14, 1945; two paratypes, Fairfield Co., Ohio, May 12, 1947.

The unique coloring and raised blackened tip of scutellum, which is reminiscent of the genus *Hymetta* make this form very outstanding. It may be related to *E. lunata* McAtee, and fits the description fairly well, but the genitalia are quite distinct from those illustrated by Beamer³ (Fig. 5), and nearer to those of *E. septima* Beamer³ (Fig. 69). The dark markings in *E. hymettana* are much broader, and more diffuse than in either of the two species, and it is more definitely a member of the Maculata group.

Erythroneura luculenta n. sp.

Large, background white, semihyaline with orange to red markings. Vertex more sharply produced than in most members of the Maculata group and with more pointed apex. Vertex marked with five oral white spots surrounded by vittae in which red coloring is accentuated in two median basal and median apical dashes. Pronotum white with median heart-shaped spot and small angulate mark behind either eye. Scutellum pale in holotype, red tipped and yellow basal angles outlined in red in some specimens. Clavus with anchor spot on basal half, spot before apex; small humeral spot, and angulate vitta on corium surrounding plaque and extending over to area below apex of clavus. Outer crossveins and adjacent longitudinal veins reddened, latter only briefly and before crossveins. Large round black spot in base of M_4 and smaller one at posterior margin of plaque. Tips of wings clouded faintly.

♂ *genitalia*. Pygofer hook heavy on basal half, tapering to sharp tip on outer half which is curved in distinctly. Style small, base curved, heel large, protruding, less than right angle;

³R. N. Beamer, Can Ent., 64: 174, 1932.

anterior point small, projecting; posterior point longer than foot, narrow, tapering to fine point, meeting base at less than right angle. Aedeagus short, quadrate, rough lateral edges, appearing cut off in lateral view, and broader at tip than at base; almost quadrate in ventral view.

Length: 3.2 mm.

♂ holotype, Oak Creek Canyon, Arizona, August 1, 1938, allotype August 15, 1938; ♀ paratypes, 1 August 1, 1938, 2 August 15, 1938, 1 July 13, 1940; 2 ♀ paratypes, Flagstaff, Arizona, July 30, 1938.

Runs to *E. dira* Beamer in key⁴ but is closer in general appearance to *E. lorella* Rob. from which it differs chiefly in form of aedeagus.

***Erythroneura uvaldeana* n. sp.**

Rather small species with ground color white to cream, semihyaline on elytra, marked with golden orange to scarlet. Vertex with narrow elongate median pale oval margined entirely and evenly with broad vitta which on either side at middle has fainter lateral extensions to eyes. Pronotum with large median Y almost reaching both margins, large triangular spot behind each eye. Scutellum with basal angles yellow orange and apex orange. Elytra with basal anchor spot on clavus, another before apex; irregular marking extending from below outer humeral angle on corium, around costal plaque and from its lower inner corner obliquely to area below apex of clavus. Outer crossveins and adjacent longitudinal veins reddened, inner pale. Small black spot in base of cell M₄, a minute one at lower edge of plaque; tips of tegmina fumose. Highly marked specimens taken in June have elytra vittae broad and continuous.

♂ genitalia. Pygofer hook narrow to outer half, where it broadens slightly and forms two spines at its apex, outer a short sharp spine continuous with outer margin, inner much larger, and turned in abruptly at not much more than a right angle from outer spine. Style with medium foot with fairly heavy, straight base; rectangular heel and anterior point; posterior point a short sharp incurved barb, about $\frac{1}{4}$ length of foot. Aedeagus as long as foot, a straight narrow tube from any view.

Length: 2.8 mm.

Described from twelve specimens from Uvalde, Texas collected by D. J. & J. N. Knull.

♂ holotype and allotype, 2 ♂ and 4 ♀ paratypes, August 4, 1937; 2 ♀ paratypes, June 3, 1939, 2 ♀ paratypes, June 26, 1940. These were taken from oak in Garner Park.

Near *E. bispinosa* Beamer, but differing in form of apical spines of pygofer hook and form of aedeagus.

***Erythroneura severini* n. sp.**

General ground color creamy white, semihyaline elytra, markings orange, small and distinct. Vertex with faint traces of median orange-encircled oval; pronotum with small median triangle in middle; angles of scutellum deeper cream. Clavus with narrow basal anchor-shaped vitta not touching any margin and small spot before apex; corium with four spots around plaque and one above cell M₄; crossveins irregularly red, dark spot on base of cell M₄ small. Venter cream and white.

♂ genitalia. Pygofer hook single, stout, broader near middle, slightly S-curved, tapered to sharp apex; style with narrow foot, base straight, heel a little sharper than a right angle, anterior point projecting slightly, posterior point longer than foot, narrow, straight-sided, sharp. Aedeagus long and narrow, straight, with a few spines in front.

Length: 2.5 mm.

Holotype ♂, allotype, 3 ♂ and 1 ♀ paratypes, Hot Springs, S. D., Sept. 17, 1919; 1 ♂ and 1 ♀, August 27, 1922, Raspberry, H. C. Severin. Two paratypes sent to Dr. Severin, for whom the species is named.

Resembles *knighti* Beamer, but has narrower aedeagus and shorter pygofer hook. Runs to *E. usitata* in Beamer's key.⁴

***Erythroneura direpta* n. sp.**

General ground color yellowish white to semihyaline. Markings orange to red, diffuse. Vertex with three white spots surrounded by narrow irregular orange bands. Pronotum with

⁴R. H. Beamer, Can. Ent., 64: 174, 1932.

median Y-shaped vitta and spot back of each eye. Scutellum with orange spot on tip and basal angles yellow. Clavus with basal anchor-shaped spot and one near apex; corium with spot on costal at humeral angle, irregular one at anterior end of costal plaque, two streaks at posterior end, rectangular one at clear space opposite apex of clavus and a streak before base of cell M_4 . Medium sized black spot in base of cell M_4 and small one in posterior end of plaque. Venter cream.

♂ *genitalia*. Pygofer hook single, heavy, straight, turned in slightly toward tip, very slightly enlarged before apex; style with large foot, base curved, heel prominent, anterior point distinct, blunt, posterior point longer than foot, narrow, sharp-tipped, inner margin irregular. Aedeagus oblong with spiny irregular apex, longer behind than in front in lateral view.

Length: 2.5 mm.

Holotype ♂ Hocking Co., Ohio, July 16, 1945; *allotype*, April 26, 1938; *paratypes*, 2 ♂, April 17, 1938; 3 ♂ and 1 ♀, April 26, 1938; 1 ♂, May 8, 1937; D. J. & J. N. Knull. 5 ♂ *paratypes*, Ashland Co., Ohio, Sept. 29, Mary Auten. Delaware Co., Ohio, 3 ♂, May 19, 1943, Sept. 4, 1944, Oct. 3, 1943, D. J. & J. N. Knull. 3 ♂, Knox Co., Ohio, August 28, 1933 Mary Auten; 3 ♂, Scioto Co., Ohio, June 1, 1945, D. J. & J. N. Knull.

Close to *E. certa* Beamer in character of inner male genitalia and also resembles *E. dira* Beamer, but differs from the former in longer base of style, and from latter in longer aedeagus and pygofer hook.

Erythroneura proluxa n. sp.

General ground color white marked with broad orange vittae. Vertex with three oval imperfectly orange-margined pale spots. Pronotum with median Y reaching both margins, large angular spot behind each eye. Scutellum with apex orange, basal angles yellow, outer margins orange. Clavus with basal broad anchor-shaped spot, elongate spot before apex; corium with diagonal vitta below humeral angle to anchor spot of clavus, one on three sides of plaque with diagonal extension toward apex of clavus. Crossveins red, black dash at posterior end of plaque and large round black spot in base of cell M_4 . Below, white and cream.

♂ *genitalia*. Pygofer hook extraordinarily long, almost as long as style, gently S-curved, wider at inner curve near middle, sharp-tipped. Style large, base broad, straight; heel large, projecting slightly, anterior point projecting about 45° angle, posterior point narrow, sharp, straight, meeting base at about a right angle, a little shorter than base. Aedeagus long, smooth, oval.

Length: 3 mm.

♂ *holotype*, Hocking Co., Ohio, May 5, D. J. & J. N. Knull; 1 ♂ *paratype*, Pickaway Co., Ohio, Febr. 20, J. S. Caldwell.

Nearest *E. inconstans* Beamer, from which it differs in shape of aedeagus and width of style.

Erythroneura malaca n. sp.

Anterior ground color cream, of elytra white semihyaline, markings pale orange, eyes dark. Usual markings of head, pronotum and scutellum faintly indicated. Clavus with basal anchor and spot before apex, corium with dot at humeral angle, two irregular parallel bands originating at each end of plaque and extending, anterior one to spot near apex of clavus, and posterior to point below apex of clavus, outer crossvein bright red, black spot in base of cell M_4 and dot in posterior margin of plaque, apices smoky hyaline. Below cream colored.

♂ *genitalia*. Pygofer hook long, straight, heavy, a little broader below middle, tapered to sharp tip. Style with large slender foot, base straight, heel protruding, anterior point short, less than right angle, posterior point meeting base at less than right angle curve, directed in, almost as long as base, narrow, sharp. Aedeagus triangular, tapered to spiny tip, longer than broad.

Length: 2.75 mm.

♂ *holotype*, Highland Co., Ohio, June 6, 1945, D. J. and J. N. Knull; 1 ♂ *paratype*, Lawrence Co., Ohio, April 29, J. S. Caldwell.

Near *E. macra* Beamer but with stouter, straighter pygofer hook.

All specimens of *Erythroneura* are retained in collection of author unless other deposition is mentioned.

A NEW SPECIES OF DRAECULACEPHALA FROM CALIFORNIA (HOMOPTERA, CICADELLIDAE)

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This new species closely resembles *Draeculacephala minerva* Ball and at first was thought to be the same but attempts at cross-breeding have been unsuccessful thus indicating that it is definitely new. It has been proven to be a vector of a virus disease of grapes in California.

Draeculacephala californica n. sp.

Resembling *minerva* in general appearance this species is slightly longer and narrower bodied with the vertex more produced and the apex of the vertex more acute. In profile view the face is slightly concave while in *minerva* it is slightly convex.

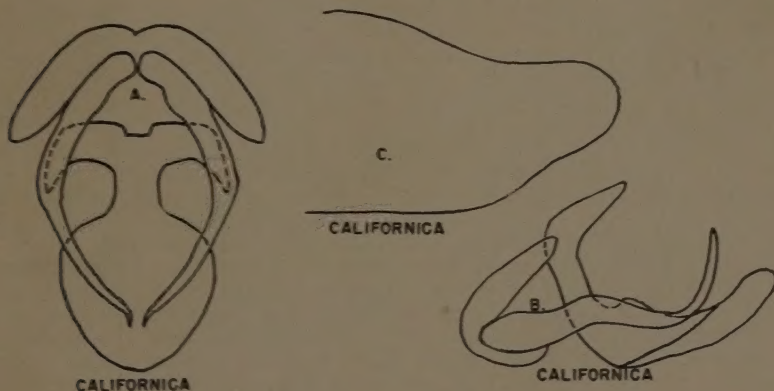


FIG. 1. A. Ventral view of internal male genitalia. B. Lateral view of internal male genitalia. C. Lateral view of pygofer.

Color: The vertex, anterior portion of pronotum and scutellum are greenish-yellow. There are also a few very faint brownish lines on the vertex. The posterior portion of the pronotum and elytra are dark green with pale green veins. The body of both males and females is light yellow to cream color beneath with slightly darker colored faces, while in *minerva* the face and underside of the body of the male is black and in the female light yellow.

Genitalia: In the female the last ventral segment has a median produced, rounded apex and concave lateral angles. The male plates are nearly as long as the pygofers and gradually narrowed to pointed rounded apices. The styles are short and broad with the apical portion bent inward and narrowed abruptly to sharp pointed tips. The aedeagus in lateral view has a pair of short, stout, dorsally-directed basal processes. Posterior to them is another pair of long, slender

processes which from ventral view curve outwardly at half their length and then inwardly, gradually tapering to slender pointed tips which are directed upward. The basal portion of the aedeagus proper is bifurcate with stout, dorsally-directed pieces. It has a ventral, convexly rounded, broad portion with a gently rounded apex that is directed posteriorly and upward.

Holotype male, allotype female, and a male and female paratype in the Ohio State University collection were all collected by the junior author at Oasis, California, on May 28, 1946. A pair of paratypes from the type series is deposited in each of the following collections: U. S. National Museum, Washington, D. C., Snow Collection, University of Kansas, University of California and California Academy of Science. Twelve pairs of paratypes from the same series, and seven male and ten female paratypes from Oasis, Calif., collected on 6-6-42 (Frazier), and one male and three female paratypes from Berkeley, California, June 1942 (Frazier), are all deposited in the collection of the junior author. One female and ten male paratypes from Brawley, Calif., (Webster No. 7090); seven male paratypes from Yuma, Arizona, July 20, 1907; a pair of paratypes from Yuma, Arizona, June 11, 1937, collected by D. J. and J. N. Knull; one male and three female paratypes from Holtville, California, collected by V. L. Wildermuth; a pair of paratypes from El Centro, California (Webster 7089); one male paratype from Imperial, California, collected by V. L. Wildermuth; and one male from Palo Alto, California, July 14, 1892, all in the Herbert Osborn Collection, Ohio State University.